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Developing MaaS business models
Business models for MaaS

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Abstract

Changes in the society, for instance tightening environmental and financial targets, require new ways of organizing transport and mobility. Cities have challenges with emissions and congestion while rural areas have problems organizing transport services efficiently due to long distances, sparse population and narrow flows of people and goods. Thus, a collaboration of different stakeholders and combining different transport services are a prerequisite for viable and attractive MaaS services. MaaS business models presented in this study are based on the findings of two MaaS projects: European MAASiFiE project studying the MaaS concept widely at European level, and a Finnish MaaS project concentrating on identifying and developing preconditions for accessible and lasting rural mobility.

The business models can facilitate the development of MaaS services in different contexts, and especially in rural areas by offering extensive business models for service development. The focus is especially on MaaS durable business models for rural areas including the organizing of statutory social and health service transportation, which inefficiency has been a big debate in Finland. A total of five business models were identified including two commercial ones, one publicly operated and two different kinds of public-private models. The paper also discusses service agreements and revenue models of MaaS.

KEYWORDS Mobility as a Service, MaaS, business models, mobility, transport, services, rural

Introduction

Current megatrends, such as urbanization, climate change, globalization, digitalization and demographic shifts are constantly affecting the movement of people and goods – some changes happen faster and some slower. However, most of these megatrends and trends are causing pressure to intensify and decarbonize the current transport system. For example, when housing is concentrated in urban areas and the current transport system is firmly based on the usage of private cars, it is hard to reduce congestion and emissions with traditional transport solutions. However, digitalization can be seen as an exception to other megatrends, because at the moment the common understanding is that digitalization will mostly result in positive impacts in the transport sector by providing new kinds of solutions to support remote working for example. In general, digitalization and IT-related services are seen to provide new solutions and improvements to connectivity, transparency, situational awareness and effectiveness of the transport system. (Pöllänen et al., 2015)

Mobility as a service (MaaS) is an emerging mobility concept that heavily relies on digitalization and an end-user oriented approach. The great vision in the MaaS concept is to connect all available transport and mobility services in a one-stop-shop package and hence provide an agile, sustainable and efficient competitor to private cars, which can be tailored according to the needs of end users. Since the MaaS concept is holistic and still emerging, it can be defined and approached from many different points of view, but the definition adopted in this study is the same definition within the MaaSiFiE project, namely: “Multimodal and
sustainable mobility services addressing customers’ transport needs by integrating planning and payment on a one-stop-shop principle” (König et al., 2016).

The purpose of this paper is to present potential business models for Mobility as a Service, by presenting and analyzing existing business models of MaaS operators and pilots, which were identified in the international research project titled Mobility as a Service for Linking Europe (MaaSFiE) and national research project titled Mobility as a Service Concept - promoting service and livelihood development in rural areas (Rural-MaaS). The study consists of seven sections, where the first two present a general background and connect the study’s context to the theoretical background. Sections 3 describes the background and methodology employed. Section 4 introduces MaaS cases analyzed in both projects and the fifth section the MaaS business model illustrations. Section 6 consists of the main findings and Section 7 summarizes the study.

Attaining competitiveness through a robust business model

Every successful company has a sound business model (Johnson et al., 2008; Magretta, 2002). Various definitions of a business model exist, for instance a business model explains how enterprises work (4). A successful business model answers fundamental questions such as “Who are the customers and what do they value?”, “How is money generated in this business?”, moreover, “How can the value be delivered to customers at an appropriate cost?” Business models force managers to thoroughly think about their business and assess how well all the elements of a system fit together as a whole (Magretta 2002).

Some researchers have defined business models more formally. Most of them relate to the company’s logic for creating and capturing value, which are the most fundamental functions that all organizations must perform to survive and stay competitive (Shafer et al., 2005). Osterwalder and Pigneur (2013) state that: “a business model describes the rationale of how an organization creates, delivers, and captures value”. Business model innovation is the only way to avoid competition even temporarily.

Additionally, a business model itself can provide a competitive advantage if the model is sufficiently differentiated to meet particular customer needs and is hard to replicate (Teece, 2010). An appropriate business model is also required for commercialization of new ideas and technologies. Otherwise they have no objective value and their economic value will remain latent (Chesbrough 2010).

A business model is usually described as containing three elements that explain how value is created: value proposition and providing, value creation system, and revenue model (i.e., value capturing) (Pekuri, 2015). A business model is built on customer value since the ultimate purpose for a buyer and seller engaging in a relationship is to work together in a way that creates value for them. Sometimes value is just defined monetarily, although nowadays a broader definition is often utilized that also includes non-monetary revenues, such as competitive advantage, competence, customer experience, market position and social rewards.

Successful companies find a way to create customer value (Magretta, 2002), but only some companies have been able to define and measure created customer value (Anderson and Narus, 1998). To make customers focus more on total costs (i.e., life-cycle) rather than only on acquisition price, a supplier must have a clear understanding of what is of value to their customers. The providing covers the output of the value creation system including both products and services. Companies strive to solve problems of the customers and satisfy their needs with the providing and hence the primary objective of any offering is to provide value to a particular customer segment (Teece, 2010).
The last part of the business, value capturing, is commonly forgotten (Osterwalder and Pigneur, 2013). Unfortunately, this means that companies also fail to achieve revenues relative to the value they create. Value capturing measures a company’s ability to translate its value proposition into revenue sources (Osterwalder, 2004). Usually, companies do not have just a single revenue stream because they may have different pricing models for different services or products. Therefore, their revenue models should be in line with the markets in which they compete.

Overview and methodology

In this study, the findings and analyses are mainly based on qualitative data. It has been collected via a literature review and expert interviews, which were conducted within the MaaSiFiE project during the spring of 2016. To understand the current and forthcoming challenges and preconditions for the mobility and accessibility of transport in rural areas a literature review and a set of national expert interviews extending the knowledge gained in the MaaSiFiE project was conducted within the rural-MaaS project.

MaaSiFiE (2015-2017) was a two-year project financed by the CEDR (Conference of European Directors of Roads) Transnational Road Research Programme (MAASiFiE, 2016). The goal of the project is to analyze the state-of-the-art and future trends of Mobility as a Service concepts including multimodal traveler information services, ticketing/payment systems and multimodal or sharing concepts. The MaaSiFiE project also develops business and operator models, as well as analyzes potential impacts, technological requirements and interoperability issues, legal enablers and challenges. The main expected results of the MaaSiFiE project are a medium-term European Roadmap 2025 and recommendations for the implementation of MaaS. The roadmap includes roles and responsibilities of different stakeholders and especially national road administrations. Thus, the understanding of different existing and emerging business models is seen to be crucial to the MaaSiFiE project and all the MaaS stakeholders.

Rural-MaaS (2016-2017) was a yearlong national project co-funded by the Ministry of Agriculture and Forestry (rural-MaaS, 2017). The project aimed at creating a national vision for MaaS in rural and sparsely populated areas focusing mainly on recognizing emerging and potential business models for both commercial and publicly supported transport services. The project also improved the awareness of MaaS concept in rural areas by sharing knowledge but also by providing measures and recommendation for the development of mobility regulation and on technical aspects of the new mobility services.

During the projects, literature reviews made identification of existing MaaS pilots and operators easier and helped to formulate a general understanding of MaaS state of the art and the business and operation models used by MaaS service providers. In addition, the current literature was used to connect MaaS business models to the general business model theories. Because the MaaS concept is still developing, the availability of MaaS-related scientific studies is still insufficient, and thus the primary focus of the literature review was on the websites and public material of the MaaS operators and pilots.

Expert interviews (Table 1 and 2) were used to form a more sophisticated and concrete understanding of the business and operation models of the exploited business models in the identified MaaS cases. The interviews were an essential part of collecting data, because the public material and websites of the operators are mainly meant for the exact target audience such as end users, and therefore business and operation models are explained relatively universally on websites. Analyzed MaaS business model cases are listed and described below in the next section.
Because informal discussion and flexibility were considered essential for this study, the interview questions were relatively broad and loosely defined and followed more like theme interview structure. The interviews aimed at forming a robust view of both current and expected potential business models, transport service providers and service descriptions, and service combinations in different regional areas. Because MaaS is holistic concept and hence it touches various societal levels and various stakeholders, the interviews were carried out both with public organizations (e.g., public and road authorities) and private organizations (e.g., service and product providers) to identify roles and responsibilities of different stakeholders.

Table 1 – MAASiFiE interviews

<table>
<thead>
<tr>
<th>ASFINAG, Austria</th>
<th>VR, Finland</th>
<th>SNCF, France</th>
<th>E-Mobility, Austria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victoria Swedish ICT, Sweden</td>
<td>Finnish Taxi, Finland</td>
<td>Gothenburg University, Sweden</td>
<td>Sunfleet carsharing, Sweden</td>
</tr>
<tr>
<td>DLR, Germany</td>
<td>Tuup, Finland</td>
<td>Tieto, Finland</td>
<td>Trivector, Sweden</td>
</tr>
<tr>
<td>Ubigo Innovation, Sweden</td>
<td>MaaS Global, Finland</td>
<td>Forum Virium Helsinki, Finland</td>
<td>Finnish Transport Agency, Finland</td>
</tr>
<tr>
<td>Telia Company, Finland</td>
<td>Region of Västra Götaland, Sweden</td>
<td>Ministry of Transport and Communications, Finland</td>
<td>Finnish Transport Safety Agency, Finland</td>
</tr>
<tr>
<td>Sito, Finland</td>
<td>Siemens, Finland</td>
<td>Samtrafiken, Sweden</td>
<td>ÖBB, Austria</td>
</tr>
<tr>
<td>Västrafrik public transport, Sweden</td>
<td>ÅF Consulting, Sweden</td>
<td>Trafikkontoret, Gothenburg, Sweden</td>
<td>Vinnova, Swedish innovation agency, Sweden</td>
</tr>
<tr>
<td>Mobisoft, Finland</td>
<td>PayiQ, Finland</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 – Rural-MaaS interviews

<table>
<thead>
<tr>
<th>Association of People with Disabilities</th>
<th>Ministry of Agriculture and Forestry</th>
<th>Regional Council of South Karelia</th>
<th>The city of Rovaniemi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre for Economic Development, Transport and the Environment of Lapland</td>
<td>Ministry of Agriculture and Forestry</td>
<td>Soite - Central Ostrobothnia joint municipal authority of social and health service</td>
<td>The council of rural policy MANE</td>
</tr>
<tr>
<td>Centre for Economic Development, Transport and the Environment of South Ostrobothnia</td>
<td>Municipality logistics of Finland</td>
<td>South Karelia Social and Health Care District</td>
<td>The hospital district of Lapland</td>
</tr>
<tr>
<td>Centre for Economic Development, Transport and the Environment of Southeast Finland</td>
<td>Petri Pekkala (trade name)</td>
<td>Tampere University of Technology</td>
<td>The hospital district of North Ostrobothnia</td>
</tr>
<tr>
<td>Finnish Transport Safety Agency</td>
<td>Posti Group Corporation</td>
<td>Technical Research Centre of Finland</td>
<td>The social insurance institution of Finland (Kela)</td>
</tr>
<tr>
<td>Growth Corridor Finland</td>
<td>Regional Council of Central Ostrobothnia</td>
<td>The Association of Finnish Local and Regional Authorities</td>
<td>Tuomi Logistics Ltd.</td>
</tr>
<tr>
<td>Linna business development (Hämeenlinna)</td>
<td>Regional Council of Lapland</td>
<td>The city of Hämeenlinna</td>
<td>Uber Finland</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The city of Imatra</td>
<td>Visit Rovaniemi</td>
</tr>
</tbody>
</table>
MaaS business cases

The MaaS business model cases analyzed in this study are: Tuup, Whim by MaaS Global; Telia Finland – Ylläs Around and Sonera Reissu; Sito – Kätevä Seinäjoki; Kutsuplus - Helsinki Region Transport (HRT); SNCF – iDVROOM, iDCAB, iDAVIS, iDPASS; UbiGo; and SMILE/Beam-Beta. The selected cases represent state of the art in field of multi- and intermodal transport and mobility in urban, suburban and rural areas.

Tuup (Finland)

Tuup is a Finnish mobility service providing access to all the locally available transportation options through a mobile application. The service is marketed for travelers, cities, municipalities and even for enterprises that want to make work-related trips more cost-effective and to steer employees to use sustainable transport solutions. Tuup's mobile application has been available since April 2016 and currently the service includes the information on the prices, routes and timetables of the available transport; either it is public transportation, taxi, rental car, bicycle or a combination of these.

The application also reminds users about the upcoming trips, deviations, pick-up locations and the general real-time traffic situation. The Turku Region Traffic, also known as Föli, was the first mobility service providing ticket purchase via Tuup. (Tuup, 2017). Tuup has also launched Kyyti taxi-pooling service in three cities in Finland: Turku and its neighboring municipalities Naantali, Raisio and Kaarina, and the cities of Oulu and Tampere. Kyyti provides dynamically priced taxi rides and it is a first-/last-mile solution. The service has thousands of registered users by now and it delivers hundreds of rides daily (Honkanen, 2017).

Whim by MaaS Global (Finland)

MaaS Global is a private Finnish mobility service provider (established in 2015) owned by a group of Finnish national and international transport and mobility service providers. The company has an application, Whim, through which MaaS Global provides two different mobility packages on a monthly basis based on user needs. The application also provides an option to travel on a pay per ride basis. In addition, fully tailored packages can be provided to business users. (MaaS Global, 2017)

Whim contains travel planning, routing and mobile ticketing for mobility services such as public transport, taxis and rental cars. City bikes and bike sharing should be available soon. For the travelers, the application is free of charge but the user pays for the mobility services via their package’s mobility points. A number of monthly points depends on the selected packages. All the fees and pricing used in the service are based on the bilateral agreements between MaaS Global and transport service providers. (MaaS Global, 2017)

Ylläs Around by Telia Finland (Finland)

Telia’s Ylläs Around public-private-partnership (PPP) service is a two-year MaaS pilot in the Ylläs ski resort area in Northern Finland. The pilot started in spring 2016 and will continue at the beginning of skiing season 2017, if the service is considered feasible. The service is a part of the Aurora Snowbox test ecosystem managed by the Finnish Transport Agency and is operated by Telia Company in cooperation with the primary stakeholders: local transport operators, local municipality Kolari, Ylläs Travel Association and the Finnish Transport Agency. (Telia company, 2017a)
The primary goal of the Ylläs Around to provide one-stop-shop transport and mobility services in the Ylläs ski resort area and connect it with the main local transport hubs, Kittilä airport and Kolari railway station. The Ylläs Around contains multimodal transport services available through a mobile application, which also includes mobile payment and ticketing. All the fees and prices are based on bilateral agreements between the MaaS operator and transport service providers, such as fixed taxi prices and minor commission fees on re-sold bus trips. (Telia company, 2017a)

Sonera Reissu by Telia Finland (Finland)

Sonera Reissu provided (pilot was carried out in 2016) transport services in the city of Hämeenlinna for rail/bus and (shared) taxi. The Reissu service strived to provide mobile application enabling end user trips on a one-stop-shop basis. The application comprised mobile payment and ticketing and it combined both taxi and train/bus trips to Helsinki on the same ticket. However, it preserved separate ticket IDs according to the service providers’ ticketing systems. Sonera Reissu had fixed prices for taxies depending on the distance from Hämeenlinna city center, and it took a minor commission fee on re-sold train tickets. (Telia company, 2017b)

Kätevä Seinäjoki by Sito (Finland)

Sito Ltd. coordinated Kätevä (“Handy”) Seinäjoki MaaS pilot in the municipality of Seinäjoki from November 2016 to April 2017. The first phase of the pilot was funded by Tekes, the Finnish Innovation Agency. Kätevä mobile application integrates traditional bus and taxi services and therefore provides more agile and handy travel chains. The pilot involved 20 travelers as a test group and included the following services: taxi, shared taxi, on-demand and traditional route- and schedule-based public transport, city bikes and walking. The service had three different priced monthly packages. Currently Sito ltd. is mapping out the options to carry out and develop the pilot further. The aim is to enlarge the test group and add more services at least. The Kätevä application is available for IOS and Android. (Kätevä Seinäjoki, 2017)

HRT Kutsuplus (Finland)

HRT (Helsinki Regional Transport) Kutsuplus service was one of the first large-scale pilots which strive for reinventing carpooling for the algorithm age. The public operation started in 2013 and lasted until the end of 2015 when there was 15 vehicles in use. By providing an on-demand minibus service combining traditional taxi and city bus services into one, Kutsuplus tempt motorists to switch to public transport. (HRT, 2016)

Kutsuplus used a dedicated algorithm to optimize and route scheduled and spontaneous trips heading roughly in the same direction. The Kutsuplus service was available in the Helsinki metropolitan area on daytime, when it provided the option to travel in the city area cheaper than with a traditional taxi service but much more flexibly than with the normal public transport bus service that only has fixed routes. To have a ride required logging in the service website and filling in the origin and destination, and finally walking to the closest bus stop to wait for the pick-up. The price depended on the following aspects: traveled distance, the number of other passengers, and the flexibility on waiting and pick-up time. Kutsuplus provided a worthy option for transverse traveling against main public bus lines to and from the Helsinki city center. (HRT, 2016)
SNCF (France)

SNCF is a French nationally, state-owned railway company, which offers several service combinations based on the new multimodal services. This development aims to tempt more train use via improved customer experience and integrated services. The results so far have been positive. The ultimate goal is to be able to provide door-to-door services that could be integrated with international services. Currently SNCF mobility initiatives listed below:

- **iDVROOM** is a car pooling service. Frequent users have a guaranteed return journey by taxi if the driver unexpectedly cannot bring one back. iDVROOM also offers a free automatic toll badge, no management costs, and a monthly downloadable invoice. (SNCF 2017a)
- **iDCAB** is a taxi or equivalent with fixed price and advance payment. The reservation can be done on the website iDCAB or using the iDPASS application. (SNCF 2017b)
- **iDA VIS** makes a simultaneous booking of rental car and train ticket possible. Users possessing a discount or loyalty card will get reduced prices. The service is available at over 170 railway stations in France and over 90 stations across the Europe. (SNCF 2017c)
- **iDPASS** is a mobile application for door-to-door transportation planning for the first and last mile. The mobile application includes: Wattmobile, a self-service electric vehicle rental service; Zipcar, a self-service car rental/sharing service; bike sharing service pointing out the locations of self-service bicycle stations and the number of available bikes; Parking feature visualizing the available parking places nearby and navigation to the destination. (SNCF 2017d)

UbiGo (Sweden)

In Gothenburg, Sweden, the Go:Smart project ran a six-month (November 2013 - April 2014) Field Operational Test (FOT) of the UbiGo service, involving around 200 participants from private, urban households. The objective was to test the business concept and the service looked to reduce or eliminate the need to own a (second) private car. Even though the test-users were highly satisfied and used the service to test new and more sustainable travel behaviors, the service was ceased after the pilot ended since there was difficulties in finding an appropriate cooperative model that worked for both the region/PT-provider and UbiGo as an emerging private, commercial service (Sochor et al., 2015a; Sochor, 2015b).

UbiGo operated on a reseller basis, based on bilateral agreements between transport service providers. UbiGo included a relatively inclusive set of features and services:

- access to public transport, bike and car sharing, taxi and rental cars; a personalized, monthly household subscription (and single invoice)
- a customer service phone line serving 24/7; subscription access via a smartphone, in which users could activate tickets/trips, make/check bookings, etc.
- a smart card, used for instance to check out a bicycle from the bike-sharing service or unlock a booked car, but also charged with extra credit for the public transport system in case there was any problem using the UbiGo service.

BeamBeta/WienMobil-Lab (initiated by the SMILE project)

The SMILE project, ended in 2015, provided an enabling platform for integrated mobility based on the multimodal traveler information platform VAO (Verkehrsauskunft Österreich), which development started by public transport associations and financed through public projects. The SMILE engaged 1000 external users who tested SMILE over several months. Based on their questionnaire results, the project had positive
effects on transport mode usage; for instance according to 26% of respondent, they have changed their habits towards less use of private cars. (Smile mobility, 2014)

As a follow-up to SMILE, Beam-Beta (Fluidtime, 2017) is in development and currently mainly public or partly public-owned organizations are involved in the SMILE and Beam-Beta pilot activities. Providing integrated multi- and intermodal information services combined with mobile and ticketing, payment as well as shared-mobility features, e.g., real-time routing and dynamic timetables, traffic events information (including road, public transport, trains, cycling, walking and intermodal transfer points) is a vital part of SMILE and BeamBeta. Both pilots provide all these services on a one-stop-shop principle over one standard application programming interface (i.e., API).

MaaS business and operator models

The MaaS concept strongly rest upon a data platform approach enabled by the digitalization. For the transport sector this means a new way of thinking which may confront some resistance from the traditional actors. Apparently it may take some time to gain end-user acceptance too. However, MaaS also requires interoperable solutions which not only require a more inclusive understanding of available solutions and customers’ needs, but also exploitation of new value capturing models. MaaS operators are mostly acting as an intermediary between customers and service providers and hence it is crucial to understand the needs of both and to enable the development of agile, integrated solutions by dispensing an appropriate middleware environment or B2C interface with several fit-for-purpose payment methods.

All MaaS business models seem to have a wide mutual range of key stakeholders and customers as well as revenue streams, which ultimately illustrates the business potential of MaaS. A range of involved stakeholders simultaneously enables but also requires the development and provision of interoperable and integrated services, where some stakeholders attract more customers than others. Based on the case analysis, several business models with different approaches exist when the MaaS operator can be either a private, a public entity or a mix of those.

Figure 1 describes two operator models – reseller and integrator – that would probably be managed by commercial MaaS operators. The reseller model rests upon various services from several transport service providers (TSPs) that combined and provided to end users via one interface (e.g., mobile application). The integrator model contains traditional transport services extended with some extra services/features from a mobile service provider (MSP), for example key enabling technologies and services such as mobile ticketing and payment.

Figure 1 - Commercial MaaS operator models (Eckhardt and Aapaoja, 2016).
The public transport service operator (Figure 2) have traditionally been a focal actor in the transportation sector. As a MaaS operator, the public transport operator may focus on enriching its services by integrating other transport-related services into its regular service portfolio. These additional services can cover taxis, carpooling, city bikes and some inclusive digital services by the MSPs, e.g. mobile ticketing and payment, and multimodal planner and (re)routing.

Figure 2 also illustrates the public-private partnership (PPP) MaaS operator model, which in this case is mainly based on the Kätevä Seinäjoki/Sito case in Finland. As mentioned above, Kätevä Seinäjoki pilot is a collaborative initiative by a consulting and planning company Sito Ltd., the municipality of Seinäjoki, and some local transport operators proving new mobility services in Seinäjoki.

Compared to other illustrated business models, the PPP MaaS operator business model may consist of local logistics service providers (LSP) in addition to other services providers. Kätevä Seinäjoki also strives to intensify statutory social service transportation (SST), i.e. trips for disabled and elderly persons, etc., by connecting the organizations responsible for these trips to the MaaS service.

According to the initial results and findings, the PPP MaaS business model could be especially suitable in rural or sparsely populated areas, where overall transport volumes are low, but travel distances are relatively long. In an environment of this kind, efficiency is a key enabler and thus combining logistics services as well as school and statutory social service transportation together with MaaS, is seen to be an efficient solution for future development. N.B. while all operator models can include logistics services and other additional services, the PPP model usually integrates logistics services from the beginning, due to available transport capacity and long distances.

Based especially on the interviews and findings of the rural-MaaS project, Figure 3 illustrates an extended version of PPP business model, PPPP (public-private-people partnership) which is considered as a way for organizing future mobility and transport in primarily rural and sparsely populated areas and regions. In Finland, health and social services along with regional government reformation are currently ongoing in which transport and mobility as across-cutting theme present a vital role within the established regions. A growing need for integrating publicly compensated transports (i.e., statutory social service transportation) and self-paid transport exists. Public expenses on statutory social service transportation transport in Finland are too high and have reached 1 billion euros annually but simultaneously the accessibility of public transport should be improved in order provide sufficient service level through reorganized and complimentary transport
services for the citizens in rural areas. It is also worth noting that many regions may have seasonal demand factor (e.g., tourism) which increases the demand for the accessibility public transport.

Since flows of passengers and goods are mostly narrow in rural areas, PPPP model relies on the fact that interface enabling integrating private, public and commercial transport services should be established. Especially shared public and private resources (i.e., *shared resources as a part of public transport*) are seen essential for the rural mobility; it may enhance or at least sustain the service level of public transport but also enable new business opportunities and extra income for the local entrepreneurs and firms.

![Figure 3 - PPPP model for rural areas (translated from Eckhardt et al., 2017)](image)

**MaaS business and operator model analysis**

At the top level, four different MaaS operator model categories exist: commercial, public, PPP and PPPP. Moreover, commercial MaaS operator models can be broken down into two types: reseller and integrator. A reseller supplies transport services of different transport modes (e.g. a travel agency). An integrator, also, combines the services of several modes with digital services, e.g. an application for mobile ticketing, travel planning, route planner etc. MaaS can be the main business for some integrators but for the others it can be just a complement to their service portfolio.

In some cases, municipality/city-owned and state-owned public transport operators can act as MaaS operators by integrating additional transport services and digital services with their existing public transport. In the Public-Private-Partnership (PPP), the public actor may combine various types of stakeholders and services in one system, which can enhance and rationalize the services the public actor is taking care of, e.g. legislated special transport services and freight/delivery. PPPP is an extended version of PPP, targeted especially to rural areas where maintaining or even improving the quality and accessibility of public transport probably requires shared resources to be considered as a part of public transport. Figure 4 illustrates the four recognized operator model categories.
Because the history of MaaS services is still relatively short, there is not yet much evidence on the suitability and success of the illustrated MaaS business models, even though MaaS or equivalent services and pilots already exist. In addition, there are hardly any full-scale international, not mention cross-border, MaaS services providing integrated ticketing, payment and multi-/intermodal traveler information and routing. Business models will obviously evolve; the most successful will remain and the less successful will disappear. Despite the relatively early stage of the MaaS concept, multiple revenue models for MaaS operators can already be identified. The reseller business model is mostly based on commissions and hence requires high volumes since the margins are probably small. The concept provides just minor additional monetary value, but it can integrate multiple transport modes on a one-stop principle.

For the integrators MaaS can be the main business; integrator model would also require large volumes as the revenue model would probably be based on commissions on re-sold services. Additional services combined with transport services would likely be expected to increase volumes. As a common way in mobile business for having additional incomes, advertisement/marketing of other services and products could be utilized as well. An integrator may provide MaaS services to extend and complement their primary business in order to strengthen its market share and competitiveness. For instance, if event organizers, boarding houses or other non-transport service providers act as MaaS operators, transport services can be considered as additional services from their point of view. This can also improve the image of the company as providing all-inclusive service packages. Additionally, customers might be willing to pay a higher price for a trip sold by a MaaS operator, if the operator could guarantee a connection in case of delay in a multimodal travel chain.

When a public transport operator acts as a MaaS operator, the main aim is probably to increase sales and the average vehicle occupancy as well as improve the accessibility of public transport by providing a set of on-demand first-/last-mile services, more extensive and additional services. Public transport operators should also pursue the reduction of emissions in accordance with the political guidelines of the municipalities, region or state (nation). The PPP model does not necessarily aim at profits, but it can result in cost savings for the public sector through improved efficiency and more inclusive services for, in particular, vulnerable social groups or rural areas. In addition to PPP model, PPPP model takes into account the fact that in some sparsely populated rural areas and regions demand for public transports - whether it is set by the local people or e.g., seasonal tourism - cannot probably be met solely by existing public resources but they need to be integrated with both commercial and shared private resources.

In sum, PPP and PPPP models strive more than other models to improve the efficiency of existing transport services and public resources by taking advantage of the personalized approach to develop an inclusive transport system. Enabling new methods for using existing services, for example shared taxis or other forms of demand-responsive transport, may offer a more efficient use of public resources. The more personalized...
approach to mobility services could help to attract citizen who now finds difficult to use traditional public
transport, such as the elderly, the disabled or foreigners by easing access to door-to-door transport provision.

Conclusions

Business model consists of three elements that together describe the value creation: value proposition and
offering, value creation system, and revenue model. In this study, MaaS business and operator models are
described and analyzed through existing MaaS services and pilots. Five different types of models were
identified; two commercial models – reseller and integrator; the public transport operator as MaaS operator
model; and two multi-sector partnership models - the PPP and PPPP MaaS operator models. For all of these
models, a wide range of key partners and customers in addition to revenue streams, i.e. multidimensionality,
are overarching features and also essential parts of the business model.

Based on the findings, it could be summarized that the public transport operator-based model is likely to be
more common in cities, suburban areas and interurban transport because these areas and sectors are already
relatively well covered with public transport. The PPP and PPPP models can potentially bring remarkable
cost savings for the public sector but also bring huge benefits for the users in rural areas. Hence they could
be more viable especially in rural areas and together with subsidized transport and shared private resources.

The reseller model might lose its share as new, more extensive services combinations with mobile applications
emerges, therefore it can meet obstacles in the future. The integrator model might provide the most variety
regarding the implementation and is hence the most unpredictable model due to the uncertain development of
various factors, for instance service combinations, mobile services, one-stop principle and user acceptance,
that will impact on the integrator business model. Because the integrator model is purely commercial, novel
and there are only a few ongoing pilots or services, many uncertainties currently exist and hence the model
could very well disappear in the future, or it can become a huge success. Same goes with the PPPP model
that does not exist yet. However, shared resources are already seen as a vital part of future public transport in
Sweden, so the idea of combining the transport operations of different sector is not completely new. Regions,
municipalities and cities exploiting MaaS kinds of mobility services must ensure that they are accessible
and inclusive by involving all the focal stakeholders from the operators to the citizens. By this the situation
where MaaS services only addresses the most profitable part of the market leading to a two-tiered approach
to mobility can probably be avoided.

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Providing alternatives to the private car: the dynamics of business model innovation

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Abstract

This paper investigates the potential for business model innovations in the field of car sharing to bring about a sustainable reorientation of the road transport system. On the basis of interviews with different types of car sharing organisations in four Nordic countries (Sweden, Finland, Denmark and Norway), we identify different types of car sharing business models. We also examine the ways in which organisations are currently innovating these business models, focusing on the role of digital technologies, environment-friendly vehicle drivetrains, and linkages to new innovative concepts such as Mobility as a Service. We then extrapolate three transition pathways, entitled technological substitution, shared mobility and integrated mobility, discussing their potential and governance implications.

KEYWORDS: Car sharing, business model innovation, sustainable transitions, mobility as a service

1. Introduction

The decarbonisation of the road transport system is a major challenge, particularly in urban areas. Despite opportunities to ride public transport, bicycles and to walk, privately-owned cars continue to dominate mobility regimes in many cities (Kemp et al., 2011). In suburban and rural areas, our reliance on the automobile is even more pronounced.

The use of cars creates CO₂ emissions, air pollution and noise. The need to make cities attractive and liveable is conflated with problems such as congestion and lack of space, which are inherently linked to car usage. Yet the speed and scale of urbanisation makes it difficult for cities to develop efficient and sustainable transport systems (Ferrero et al., 2015). In suburban and rural areas, these types of problems are less salient, but other issues such as accessibility mean that automobiles prevail.

The resolution of transport system problems has largely been perceived as a technical challenge (Graham and Marvin, 2001), and some argue that a ‘vehicle-based paradigm’ that has prevailed for over century (Jones, 2012). Accordingly, technological innovations (hybrid and electric vehicles, biofuels, hydrogen fuel cells etc.) are often seen as the key a more efficient and sustainable transport system. Until now, this approach has failed to bring about the necessary transformations.

Mobility as a Service (MaaS), as the integration of different transport services in a single offering, is one potential alternative to our reliance on privately-owned cars. In a MaaS system, the latter is replaced by things like car and ride sharing, which are increasingly linked with a more sustainable transport system in terms of better urban management; improvements in energy efficiency and urban air quality; greater use of renewable

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1 Car sharing refers to short-term rentals of cars in different types of networks, whereas ride sharing refers to the shared use of a car for a given trip. In this paper, we focus on both car and ride sharing as they offer the possibility of making sustainability gains in the road transport system.
fuels; reduced congestion and improved accessibility (Greenblatt and Saxena, 2015; Greenblatt and Shaheen, 2015; Burrows and Bradburn 2014; Lerner et al. 2011; Rydén and Morin, 2005). Although spurred by new mobile technologies and applications, car sharing is primarily a non-technological innovation focusing on changes in travel behaviour, new markets and business model innovation (BMI) (Cohen and Kietzmann, 2014). BMI is critical to the commercialisation of new technologies (Bohnsack et al., 2014; Kley et al., 2011; Chesbrough and Rosenbloom, 2002), and scholars have noted that car sharing business models may unlock the economic potential of electric vehicle technology and assist in its adoption (e.g. Abdelkafi et al., 2013; Budde Christensen et al., 2012; Costain et al., 2012; Weiller et al., 2015) BMI has also been linked to vehicles with hydrogen fuel cells and material recirculation, akin to the principles of a circular economy (Wells 2016).

Most car sharing conglomerates such as Uber, Zipcar and Car2Go target urban areas due to the commercial opportunities available. Cities are concentrated and densely populated, and people have best accessibility to public transport. The possibility for integrating different transport modes is also largest here. Does this, however, imply that MaaS, or at least the car sharing aspect of it, is not a viable alternative in suburban and rural areas? Or can BMI overcome barriers to the adoption of car sharing in less densely populated settings? And what is the link between car sharing business models and the uptake of environmentally-friendly vehicle technologies? In this study, we seek to address these issues by posing the following research question:

*How can BMI in the field of car sharing contribute to a sustainable reorientation of the Nordic road transport system?*

The next section draws on transition theory and the literature on BMI linking the latter to niche-level processes and transition pathways. Section two also provides a background to car sharing and outlines our methods. In section three, we present our findings. Section four concludes by outlining the ways in which car sharing can facilitate linkages to technological renewal and a more general sustainable reorientation of the road transport system by tracing three potential transition pathways, one of which has integrated mobility (MaaS) at its core.

2. Theoretical background

Transition research often utilises a multi-level perspective (MLP) to examine the dynamics of transformative and sustainable innovations (Geels 2002, Geels and Raven 2006, Geels and Shot 2007, Geels and Kemp 2012). The MLP argues that transitions come about through cumulative processes within and between three analytical levels – niches, sociotechnical regimes and an exogenous sociotechnical landscape. Structural changes often start as radical innovations or transition experiments in niches. Niches are the micro-level units where radically novelties emerge following innovative experiments (Geels and Kemp 2012). Niches can exist both within or outside regimes, such as car sharing services that are delivered by start-up companies, or by separate business units within car rental companies and car manufacturers.

We reason that the potential for BMI in the field of car sharing to bring about a radical and sustainable transition in the transport system depends (at least in part) on a set of key niche-level processes. Smith and Raven (2012) describe niches as protected spaces and divide the concept of protection in a threefold manner – shielding, nurturing and empowerment. *Shielding* involves processes that remove some of the pressure for radical, path-breaking innovations to enter the market (incubators, exemptions from industrial standards, financial reliefs etc.). *Nurturing* involves processes that support the development of radical innovations. *Empowering* involves processes that make niche innovations competitive either without changing the regime (fit-and-conform) or processes that bring about changes in regimes (stretch-and-transform). These processes
are intertwined such that shielding may prepare for more active support in the form of nurturing and in turn facilitate empowering, paving the way for more radical transformations. Similarly, Kemp et al (1998 see also Hogma et al 2002) pinpoint three activities that occur within niches. First, niches support *learning processes* across various dimensions: about the imperfections of a technology and how they may be overcome, alongside organisational issues, market demand, user behaviour, infrastructure requirements, policy instruments and symbolic meanings. Second, niches support the articulation (and adjustment) of *expectations or visions*, which provide guidance and direction to innovative activities within the niche, and aim to attract attention and funding from external actors. Third, niches support the creation of *social networks* that expand the social and resource base of niche-level innovations.

In order to bring about sustainable transformations in the transport system, it is important that niches engage with technological *and* non-technological innovations. Moving from the current, unsustainable transport system towards a low-carbon mobility system requires deep structural changes in terms of vehicle technologies *and* ingrained mobility patterns (Geels, 2012). Innovations in the field of mobility services are reliant on BMI. One novel feature of mobility services is that the business model focuses on a new type of value proposition, where users purchase services (e.g. car sharing) rather than products (e.g. cars) (Williams, 2007). Given the importance of BMI for car sharing (and MaaS!), we draw on two strands of the business model literature. The first describes business models as a credible unit of analysis, and the second describes business models as a mediating device that is essential to the commercialisation of new technology (Zott et al., 2011).

One way to apply the concept of a business model as a unit of analysis is to explore the way in which organisations create, capture and deliver value (Chesbrough, 2010; Johnson et al., 2008; Osterwalder and Pigneur, 2010; Teece, 2010; Zott et al., 2011; Zott and Amit, 2010). One can use the Osterwalder canvas to analyse business models (Osterwalder and Pigneur, 2010). The canvas is comprised of nine ‘building blocks’ (see table 1): a value proposition (i.e. a product or service that is offered to customers); a customer interface; supply chain relationships; a financial model (i.e. a cost and revenue structure that distributes benefits across business model stakeholders); partners; distribution channels and other key resources and processes (Bocken et al., 2014; Johnson et al., 2008; Osterwalder, 2004; Zott et al., 2011). Further, the canvas comprises a useful means to create typologies of different business models linked to mobility services such as car sharing (Sarasini et al., 2016a).
<table>
<thead>
<tr>
<th>Building block</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer segments</td>
<td>“the different groups of people or organizations an enterprise aims to reach and serve”</td>
<td>Mass or niche market segments</td>
</tr>
<tr>
<td>Value propositions</td>
<td>“the bundle of products and services that create value for a specific customer segment”</td>
<td>Novel technology, Increased product/service performance, Customisation, Sales of function or performance, Brand/design, Low-price, Convenience/usability</td>
</tr>
<tr>
<td>Channels</td>
<td>“how a company communicates with and reaches its customer segments to deliver a value proposition”</td>
<td>Third-party retailers, Web sales, Own/partner stores, Wholesalers</td>
</tr>
<tr>
<td>Customer relationships</td>
<td>“the types of relationships a company establishes with specific customer segments”</td>
<td>Personal assistance, Automated services, Communities, Co-creation</td>
</tr>
<tr>
<td>Revenue streams</td>
<td>“the cash a company generates from each Customer Segment (costs must be subtracted from revenues to create earnings)”</td>
<td>Asset sale, Usage/subscription fees, Lending/renting/leasing, Licensing, Brokerage, Advertising</td>
</tr>
<tr>
<td>Key resources</td>
<td>“the most important assets required to make a business model work”</td>
<td>Physical, Intellectual, Human, Financial</td>
</tr>
<tr>
<td>Key activities</td>
<td>“the most important things a company must do to make its business model work”</td>
<td>Production, Problem-solving, Platforms</td>
</tr>
<tr>
<td>Key partnerships</td>
<td>“the network of suppliers and partners that make the business model work”</td>
<td>Optimisation, Risk reduction, Acquisitions</td>
</tr>
<tr>
<td>Cost structure</td>
<td>“all costs incurred to operate a business model”</td>
<td>Cost-driven, Value-driven, Fixed/variable costs, Economies of scale/scope</td>
</tr>
</tbody>
</table>

Table 1: The nine ‘building blocks’ within a business model (Osterwalder and Pigneur, 2009).

Andrew et al. (2007) notes that organisations can adopt the role of integrator, orchestrator or licensor to govern their business model. An integrator takes full responsibility for the delivery of a value proposition and can be regarded as “the sole owner and executor of the innovation – and the primary, if not the only, participant in the rewards”. In contrast, orchestrators adopt a more collaborative approach by leveraging the
skills and capabilities of partners. The role of orchestrator is similar to that of a broker, who brings together different actors via a multi-sided business model ‘platform’ (Osterwalder and Pigneur, 2010). Uber is an example of an orchestrator in that it provides a platform to match suppliers with users in the field of car sharing. Finally, a licensor allows other parties to commercialise the intellectual property inherent in a given innovation (Andrew et al., 2007).

Business models are typically designed with two objectives in mind: profitability and scalability (Sosna et al. 2010; Teece 2010; Morris et al. 2005, 2006). The latter is defined as the capacity or potential for a particular business model to expand effectively and efficiently by reaching larger numbers of customers and new markets (Jolly et al., 2012) which are associated with their fast economic growth and rising energy demand, climate change, and widening disparities between the rich and the poor. Recently, a number of claims have been made in the literature that the prospects of alternative development pathways in emerging economies in Asia are becoming more likely, and that these economies might even leapfrog Western initiatives. This paper contributes by reporting on the five most visible and established initiatives in the area of off-grid PV solar energy in India, specifically homing in on the innovative business models that are evolving. We develop a new typology of upscaling dimensions in order to analyze these five initiatives. They are found to be quite successful, but have difficulty in terms of reaching the poorest of the poor (deep upscaling). A scalable business model is thus one that can diffuse at a relatively low cost to the host organisation. One other way to consider the scalability of business models is to examine geographical scope as an element within which a business model can function (Yip, 2004). Geographical scope is an important factor in the field of car sharing as the latter may not be economically viable in less populated geographical settings (e.g. suburbs, rural areas) where a critical mass of users is lacking.

BMI is increasingly recognised as a vital component of transitions towards sustainability (Bocken et al., 2014; Bocken and Short, 2016; Boons and Lädeke-Freund, 2013; Schaltegger et al., 2016, 2012; Stubbs and Cocklin, 2008). For instance, several works have noted that BMI may unlock the economic potential of electric vehicles and assist in their adoption (e.g. Budde Christensen et al. 2012; Costain et al. 2012; Weiller et al. 2015). Technologies and business models are linked, but are distinctly separate concepts (Baden-Fuller and Mangematin 2013). Some scholars have focused on business models as a firm-level mediating devices that harness the economic value inherent in a technology and deliver it to customers as a product or service (e.g. Chesbrough 2010; Chesbrough and Rosenbloom 2002). Novel technologies are seen as useless without a functioning business model: “the inherent value of a technology is latent until it is commercialized” (Björkdahl, 2009). Hence BMI can spur the adoption of new technology (Bohnsack et al. 2014; Kley et al. 2011; Trimi and Berbegal-Mirabent 2012; Doganova and Eyquem-Renault 2009; Calia et al. 2007; Chesbrough 2007b, 2007a).

In this paper, we examine the role of car sharing business models in the deployment of new vehicle technologies such as electrified drivetrains and autonomous technology given their potential to bring about sustainability gains. We propose that focusing on the dynamics of BMI in the field of car sharing can provide insights regarding future developments in the transport system. That is, insights can be generated by understanding different types of BMI in this field; the types of experiments that are either planned and underway; the potential to deploy new vehicle technologies within car sharing systems; and the scalability of car sharing business models. To trace future developments we draw upon the literature on transition pathways. Several attempts have been to outline a set of pathway typologies (Geels and Kemp, 2007, 2006; Smith et al., 2005).
Regarding transitions related to personal mobility, one can differentiate between two pathways. The first is based on existing and prolonged attempts to bring about sustainable transformations via technological substitution, and may be referred to as “the greening of cars” (Kemp et al., 2012). Here the current automobility regime is seen to be so deeply entrenched that the only option is to resolve sustainability problems via new technologies, leaving current practices and cultural elements intact. By contrast, Kemp et al. (2012; see also Parkhurst et al., 2012) argue that an “intermodal mobility” pathway is currently traceable, and comprises a reorientation of travel practices and behaviour towards an increased focus on combined forms of transport (e.g. bicycles, cars, trains, etc.).

Little has been done to examine the types of business models that facilitate car sharing (exceptions include Cohen and Kietzmann, 2014). Car sharing business models can be divided in terms of three general characteristics. Business-to-consumer (B2C) and business-to-business (B2B) car sharing refer to service provision to client organisations and client individuals, respectively. In B2C car sharing, a company owns a fleet of cars and facilitates sharing among members. In B2B car sharing, employees are given access to a car sharing organisation’s fleet through their employer. This is also referred to as corporate car sharing or employer-based car sharing (Clark et al., 2016). Peer-to-peer (P2P) car sharing refers to existing car owners who make their vehicles available for others for hire or rental. Car sharing can be further separated into different models such as station-based (roundtrip) and free-floating (point-to-point) car sharing (Martin and Shaheen 2016). In station-based car sharing, users collect and return cars to fixed stations. Zipcar is known as the largest provider of station-based car sharing services worldwide (Le Vine et al., 2014). Free-floating car sharing enables users to begin and end a trip at different locations within a specified geographical zone. The largest operator of free-floating car sharing services worldwide is Car2Go (Le Vine et al., 2014). MaaS represents a fourth, emergent mode of car sharing is linked to the combination or integration of different transport modes (e.g. public transport, taxis, car pools, bicycle pools) in a single, intermodal mobility offering.

Car sharing is distinguished from traditional forms of car rental and taxi services in that it involves short-term rentals at hourly rates. Car sharing is particularly attractive to people who use vehicles on an occasional basis and provides access to mobility services in place of car ownership. Car sharing also enables an improved utilisation of resources through the redistribution, sharing and reuse of excess capacity. There are various types of organisations that deliver car-sharing services. Some operators are for-profit while others are non-profit. Commercial operators may have car sharing as their core business or be part of a larger organisation, such as car rental companies (AVIS, Hertz, Sixt) or car manufacturers (Volvo, BMW, Daimler).

Car sharing is still a marginal phenomenon in most countries, but several factors are driving the growth of shared mobility (Roland Berger, 2014). There are many reasons to believe that car sharing is primarily an urban phenomenon. An urban focus is pertinent given the fact that cities and urban regions struggle with increasing population density and must provide improved accessibility to citizens whilst attempting to reduce congestion and pollution problems. Urban areas and cities are also places where socio-technical transitions in mobility most likely can take place (Bulkeley et al., 2013).

In this paper we challenge the notion that car sharing is limited to urban areas by examining the types of business models that can facilitate car sharing in different geographical contexts (i.e. urban, suburban, rural and intercity travel). We use the canvas to categorise different types of car sharing business models and to explore innovative, niche-level experiments within these business models. We also examine the scalability of car sharing business models as a means to trace potential pathways towards a sustainable reorientation of the transport system.
2.1. Method

The study is based on a set of semi-structured interviews with 15 car sharing organisations and initiatives in four Nordic countries (Denmark, Finland, Norway and Sweden). A Nordic focus was adopted primarily due to the fact that the study is part of a larger project financed by Nordic Energy Research, which aims to generate insights regarding the governance of a transition to a decarbonised transport system. The Nordic focus also allows for the analysis of car sharing in a region with a somewhat coherent sociopolitical environment, culture and circumstances. Each of the Nordic countries has, for instance, a comprehensive public transport system that may be critical in a future, intermodal mobility system. When selecting respondents, we targeted a mix of car sharing organisations and initiatives, ranging between commercial operators and civil society organisations. We also targeted organisations at different stages of development, ranging from start-ups to companies that have existed for over a decade. The aim was to understand the dynamics of BMI at different stages in the development cycle.

3. Business models for sustainable forms of car sharing in the Nordic region

Collectively, car-sharing organisations use terms such as flexibility, convenience, accessibility and affordability as their unique selling points. **Flexibility** refers to the ability for users to select between different vehicles for different types of trip. **Convenience** and **accessibility** are related concepts that refer to the access which car sharing provides, i.e. the opportunity to utilise vehicles for different activities (e.g. commuting, leisure trips, hobbies, grocery shopping) whilst avoiding the headaches associated with vehicle ownership. **Affordability** refers to the opportunity to access vehicles yet avoid the total costs of ownership, as there are outsourced to private organisations or other private individuals. The advantage of this arrangement is that users can avoid costs related to parking, maintenance, insurance and so on that are fixed regardless of the extent to which vehicles are utilised.

We identified three primary business models among Nordic car-sharing organisations. We refer to these according to the role taken by each car-sharing organisation – as an integrator, orchestrator or licensor (Andrew et al. 2007). B2B and B2C business models are inherently similar and are operated by companies that act as **integrators**, that is, companies which take full responsibility for the delivery of the value proposition to the end user. In such business models, car-sharing organisations own and operate a fleet of shared vehicles that are offered to users. By contrast, P2P car sharing relies on organisations or individuals that act as **orchestrators**, who establish platforms which allow individuals to share their own assets (vehicles). Orchestrators do not own the vehicles made available to users, and typically facilitate car and ride sharing via multi-sided platforms. However, the licensing business model is less prominent in the Nordic region, and is limited to a few cases. Hence we focus on integrators and orchestrators, whose business models are summarised in table 2. In what follows, we describe the main elements of these two business model archetypes and examine the dynamics of BMI.
### Integrators

Integrators are typically private companies that offer station-based or free-floating car sharing. They are owned by entrepreneurs or by parent companies, some of which are spun-off from the automotive sector and/or the traditional car hire industry. In the Nordics, station-based car sharing is fairly well established having been adopted by a greater number of users than free-floating services, which is a relatively new concept. Following the decision by Car2Go to desist operations in Stockholm during 2016, there is currently one company that provides free-floating car sharing in the Nordics. Hence one of the major challenges associated with free-floating services is informing potential users of the basic concept of free-floating car sharing in order to convince them to adopt the service. To minimise the costs of running a free-floating service, this operator has devised an innovative pricing model that provides a discount to users that are willing to relocate vehicles. This saves the company money as they would otherwise have to pay staff to redistribute vehicles after use.

With regard to pricing models, some integrators charge monthly subscription fees, offering different packages according to the level of use required by users. One integrator in Finland offers allows up to five users per subscription, in the name of flexibility and affordability. A common feature of the pricing model among most integrators is a fee charged per kilometre and per hour of use. In addition, monthly subscription fees typically range between around €15 to around €100, depending on the company and the type of coverage offered within different packages. Some integrators offer reduced usage fees as part of a more expensive monthly subscription, and some integrators charge no monthly fee, allowing members to register gratis and with no fixed subscription periods. This allows users to purchase services on a pay-as-you-go basis as a means to provide easy and flexible access to individuals that wish to trial their services prior to adoption. Also, in some

### Table 2: Two business model archetypes in the Nordic region.

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<th>Value propositions</th>
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<th>Or orchestrator</th>
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<td></td>
<td>Station-based</td>
<td>Rental from peers’ homes</td>
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<td>Free floating</td>
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<th>Customer segments</th>
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<td>B2C</td>
<td>P2P</td>
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<td>B2B</td>
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<th>Channels</th>
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<td>Smartphone apps</td>
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<td>Social media</td>
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<th>Customer relationships</th>
<th>Integrator</th>
<th>Or orchestrator</th>
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<td></td>
<td>Looser ties based on digital surveys and feedback</td>
<td>Close ties based on continuous interactions</td>
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<th>Costs</th>
<th>Integrator</th>
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<td>Vehicle fleet maintenance and operation</td>
<td>Employees</td>
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<td>Parking fees</td>
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<td>Congestion charges</td>
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<td>Employees</td>
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<th>Revenues</th>
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<td>Monthly subscription payments</td>
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<td>Kilometre fees</td>
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<th>Key activities</th>
<th>Integrator</th>
<th>Or orchestrator</th>
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<td></td>
<td>Customer support and marketing</td>
<td>Customer research and co-creation</td>
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<th>Geographical areas served</th>
<th>Integrator</th>
<th>Or orchestrator</th>
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<tr>
<td></td>
<td>Urban, some suburbs</td>
<td>Intercity travel</td>
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<td>Urban, suburban and rural</td>
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<th>Vehicle technology</th>
<th>Integrator</th>
<th>Or orchestrator</th>
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<td>Mix of ICE and electric vehicle technologies</td>
<td>Existing vehicle stock</td>
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instances integrators offer electric vehicles at a lower cost than ICE counterparts, but this is mainly due to partnerships with municipalities that are willing to provide some level of funding to promote environmental travel.

With regard to BMI, Integrators typically experiment with improving the value delivered through their offering by developing new pricing packages with differing levels of coverage. They also expand their offers to include a wider selection of vehicles. One integrator, for instance, recently launched a light van pool in central Gothenburg, whereas another is experimenting with electric bicycles. Other experiments include the opportunity to exchange one’s own car for an equivalent during longer trips such as holidays. In such ‘extended share’ arrangements, users can temporarily post their own vehicles for utilisation in the sharing fleet in exchange for an equivalent vehicle at their holiday destination. This type of innovation is however hampered by incompatible insurance rules in different countries.

Integrators are also experimenting with new applications of digital technology. One critical area is that of ‘digital keys’, which is the name given to smartphone applications that allow users to unlock vehicles via Bluetooth technology. In the future, digital keys will likely replace existing key card systems, and will also allow for private owners to plug their vehicles into integrators’ business models, facilitating new forms of peer-to-business-to-consumer/business car sharing. This is something of a natural evolution of previous and ongoing developments where several integrators have scaled or are currently scaling their business models by entering into partnerships with municipalities, business parks and residential building owners that wish to provide car sharing for employees and residents.

Respondents noted that digital keys will also be of utility in extended share agreements, and in open or closed social circles such as families or groups of friends that wish to share a single vehicle. In such arrangements, integrators would either provide the vehicle and the booking system, or they may act as orchestrators by providing the ICT platform that is required to share privately-owned assets. Further, one integrator is experimenting with an offer that would allow Mercedes owners to access Mercedes taxis via their ICT platform. The same company is experimenting with the P2B2C/B sharing model described above. In other words, integrators are not rigidly attached to their roles and see opportunities in becoming orchestrators. Digital technology is a critical enabler for this shift.

A further focal point for integrators’ experiments is to blur the lines between different customer segments. Whilst some integrators focus more rigidly on B2B or B2C segments, others are experimenting with new types of offers that allow commuters to access a shared vehicle for private use in the evenings and on weekends. The same vehicle is then stationed at their workplace during working hours, and can be utilised by others for business trips. In connection with this, one integrator offers differentiated pricing for different types of users at different times:

“With our system, we can create one pricelist for 8am to 4pm, and another for 4pm to 8am. So we make special prices for companies during the day… and we can dedicate one car to one company between 8am and 4pm, and no normal customer can actually see the car during this time. But from 4pm we can open up to private users”.

These types of BMIs are designed to promote a greater utilisation of vehicles, and can link workplaces to commuters homes, which in many instances refer to towns, cities and their suburbs. However, one barrier to this type of development (particularly in Finland) is the tax system, which cannot delineate between different types of vehicle usage in the same contract:
“The problem is taxes. If a company buys a product from us, a different company, they don’t have to pay taxes … But if a person uses the car, for example in the evening or weekend, then they have to pay the taxes”.

Notwithstanding, this type of BMI can play a role in reducing transport emissions by encouraging sharing among commuters. One integrator claimed that their business model, despite focusing currently on city centres, can actually assist in reducing emissions via behavioural changes in commuting from suburban areas:

“…if we can get commuters that today drive their cars into the city, to instead leave the car one day per week, it’s a huge effect. It’s a 20% improvement. Do it once a month, and it’s 5% improvement right away. For no effort. We can all find one day where we are better off to leave the car at home. So that’s a kind of two-step approach for CO2 emissions to go down. Because it’s not a technical solution, but it’s actually the business model as a whole…”

Generally, integrators tend to initiate their businesses in urban centres where there is more likely a higher demand for vehicles and thus a high utilisation (i.e. sales). However, integrators typically see urban centres as a starting point and plan to expand to surrounding suburbs, particularly in the B2C segment:

“…with a big smile I can say “this is a solution for everyone”. But that’s not the way we work. The lowest hanging fruit is private individuals…that is the first step. Mainly within the city, and then slowly evolve outside of the city, focusing on commuters. And then the next step is the rest of the country, that travels into the capital frequently”

Other integrators have already extended their coverage to suburbs and smaller towns (having existed for longer, and thus having a larger customer base), suggesting that the strategy outlined in the statement above is a viable one. That is, integrators within the B2B and B2C segments generally operate their fleets in major Nordic cities, towns and some suburbs around larger cities. However, none of the integrators that participated in this study stated that they are currently focused on rural areas, and none revealed any plans to expand to these areas. This is due to the fact that integrators face challenges in developing lucrative business models in areas with lower population densities.

Generally, integrators market themselves as offering modern fleets, where users gain access to the latest vehicle models. Vehicles are typically replaced between 18-24 months of use, but in some cases the leasing periods are as short as six months. This high level of throughput is generally translated into an impetus for the introduction of more environment-friendly vehicles, and the majority of our respondents argued that they will increasingly introduce hybrid and electric vehicles into their fleets over the next few years. Some integrators already operate hybrid and electric vehicles, and some offer electric vehicles only. In addition to the unique selling points described previously, these integrators actively market themselves in terms of their sustainability credentials. One integrator that operates electric vehicles, primarily in the B2B segment, stated that:

“…what is really unique to us, I think, is that we always start from the point that we want to provide completely sustainable mobility for an organisation. It should be sustainable in the long run. It should be a factor 10 better than today’s solution…So we want to be true, truly sustainable mobility. And we are totally alone there today.”

This particular organisation focuses on combining its own services with public transport rather than volume sales, asserting that public transport is a more sustainable alternative that car travel, such that the latter should be seen as a first/last mile solution, particularly in the B2B segment.
All of the respondents welcomed a shift to increasingly autonomous vehicles in the future, and noted the potential to reduce emissions via deployment in car sharing initiatives. One respondent argued that car sharing business models can easily accommodate autonomous vehicles, and that the latter will relinquish the need to own a car at all. Another integrator, which is involved in testing autonomous vehicles, noted their potential utility as follows:

“…this could be very interesting, looking from a B2B perspective. Because then I can have an area with a lot of businesses and just tell my cars “go down there around three o’ clock in the afternoon, pick up these people and take them home”. So that could be interesting. I think that could be the way to move, but not directly free floating”.

The opportunity associated with this is that integrators can easily target areas of high demand during different periods. Respondents also noted that autonomous vehicles would reduce the need for parking spaces, which are presently a major headache (and cost) for integrators. That is, the ability to avoid parking costs would directly increase integrators’ profitability. Further, integrators would avoid having to negotiate for new parking spaces every time they introduce a new vehicle in their fleet, which in many cases is retarding the speed at which their services can be scaled. In some cities (e.g. Copenhagen), the demand for parking outstrips supply, which means that spaces reserved for shared vehicles are often taken by frustrated drivers who are willing to pay the resultant fines. One integrator that operates an EV fleet argued that autonomous vehicles will enable decentralised vehicle charging by travelling out of the city for overnight recharging, in a manner that helps to alleviate inner cities of land scarcity pressures.

In sum, the availability (and cost) of parking is a major obstacle to the scaling of integrators’ business models. One exception is Helsinki, which has 2000 parking spaces for shared vehicles. However, none of these spaces are electrified. Ironically, the high cost of parking creates incentives to increase the utilisation of free-floating vehicles:

“And then you directly understand the balance or the importance of the cars being driven. If it’s driven, I earn money and have no parking cost. If it’s standing still, I have no revenue and I have parking costs”.

In other words, assuming that free-floating car sharing results in sustainability gains, the high cost of parking actually creates the right incentives for change. However this type of incentive is limited to the free-floating segment, as station-based car sharing is subject to fixed costs for parking, regardless of the degree to which utilised. The severity of the parking problem was noted by several integrators, who requested that policymakers prioritise solutions to allow their business models to scale in a less costly manner.

Furthermore, integrators also argued that the process of establishing recharging points for EVs be prioritised by policymakers. Similar to parking, integrators must establish charging stations on a case-to-case basis and several integrators have consequently partnered with specialised suppliers that act as mediators between landowners, utility companies and car sharing integrators to provide EV charging services. Notwithstanding, establishing on-street vehicle recharging is a near impossibility in many Nordic towns and cities, such that the possibility of creating charging stations is instead restricted to parking spaces on privately-owned land. According to respondents, too costly due to the different parties involved, and too bureaucratic. One Swedish respondent commented that these difficulties mean that integrators will face significant challenges in fulfilling their obligations towards transport policy goals:

“The major thing we are working on right now is how to electrify of our fleet. We have ambitions to become green, and if we aren't fossil-free by 2030…in terms of vehicles…that would be totally unacceptable…This
actually means that we must start being able to locate one or two new spaces for charging stations a week. Every week until we’ve reached 2030. Last week there were none, and the week before that we didn’t find one. This week we won’t be able to find one either”.

Given the current limited range of EVs, setting up a more comprehensive charging infrastructure would allow for a higher utilisation of shared electric vehicles.

Regarding other policy-related issues, integrators also took issue with the fact that VAT is charged at a higher rate for car sharing than for taxi trips, and some took issue with the fact that P2P sharing is subject to a different set of tax rules than B2C and B2B car sharing, in that peers do not pay taxes until a certain income threshold has been reached. Integrators claimed that this results in an unlevel playing field between themselves and orchestrators. Integrators also argued for a relaxation of congestion charges for shared vehicles in those Nordic cities that have implemented them.

When asked what other types of actions policymakers should take to promote car sharing, integrators also argued for the creation of pilots and experiments with new BMIs. Whilst acknowledging that public funds are available for these purposes, integrators argued that policymakers should be more proactive and create a climate of openness, whereby new ideas and concepts are trialled more swiftly than at present:

“Foster openness to dare to do tests as policymakers, they need to dare to test….Dare to do pilots or tests, where you at the end can change. I would prefer to do real live testing. Do it for free floating, test it for peer to peer. Do it with the bicycle share. Do testing. Try it for six months or a year, and if that doesn’t work out, change again”.

The focus on creating an open culture for BMI was highlighted by another respondent as follows:

“Everyone wants to be the best, and everyone is trying to attract the same customer. I’m not totally convinced that this is a suitable model for a modern city; everyone developing their own, separate mobility clusters. It would be for the best if you could find…If all players could connect to a single ecosystem according to their own needs…Everyone living in Gothenburg could somehow plug into the same ecosystem, compatible with a lot of individual solutions. If I was a politician, then I’d invite all the different players, try to get the conversation going. And everyone could be open about having business interests of their own. It's nothing to be ashamed of…But is there a possibility…Could we start taking the first steps towards having such an conversation?”

Some integrators further argued that collaboration is a necessity given the strength of existing lobbyists from parts of the traditional transport sector (e.g. the automotive industry), and argued that car sharing organisations do not have the same political clout:

“…the thing is, there are not so many car sharing companies yet. They are usually small businesses. And they don’t actually have a voice when people make big decisions…”

Aside from political actions, integrators pointed out that behavioural changes are required in order to scale up car sharing. One of the key issues related to behavioural change, according to integrators, is that people are not aware of their actual transport costs and thus lack the motivation to shift towards a more economical alternative such as car sharing:

“The big challenge is that people don’t even want to know how much they pay for their own car. An average Swede works around three months a year to pay their private car, but they don’t know it, and they don’t want to know it. They clean it, they service it, and they spend a lot of time with it. Car sharing is to me quite obvious, you can pay maybe one third of your private car costs; we clean the car for them, we service it for
them, we do everything, change winter tires and everything. So for me it's quite obvious...We have problems to reach out...I think 99% because of habits, and you need to really be an early adopter to change your behaviour. It's totally a psychological problem I think”.

3.2. Orchestrators

Orchestrators vary between for- and non-profit private-sector companies to civil society organisations. The common theme is that orchestrators facilitate car and ride sharing without owning the vehicles that are shared among users. We identified two types of orchestrator that facilitate car sharing. The first facilitates more traditional forms of P2P car sharing by providing a multi-sided platform to connect private vehicle owners to users. The platform, which in practice takes the form of an online booking system, or a less formal social media network, can be used to facilitate both car and ride sharing. The second type of orchestrator is linked to the concept of Mobility as a Service (MaaS). MaaS is at an emergent stage, with several operators conducting experimental pilots and field tests throughout the Nordics. Finland and Sweden are particularly active in the MaaS field, and are among the global pioneers of the concept. Given its novelty, MaaS lacks a robust definition, but commonly refers to the combination of different transport services (public transport, taxis, car rental, car clubs and bicycle pools) in a single offering that is made available to users via a single smartphone application. MaaS aims to provide an alternative to private vehicle ownership and use by offering a ‘seamless’ intermodal service, which can transport passengers from door-to-door in a more effective way than existing public transport systems. MaaS operators act as orchestrators by signing agreements with different transport providers that are willing to act as ‘suppliers’ in a wider ecosystem, and by marketing the service to users.

P2P orchestrators facilitate car sharing by providing the means to connect providers (normally private vehicle owners) with users, typically via digital channels such as smartphone applications and dedicated online booking systems, but also via social media and, in some cases, SMS text-messaging services. The latter is useful for some demographic groups are not familiar with smartphone technology. The main value proposition is similar to that of an integrator – orchestrators aim to provide flexible, convenient and affordable car sharing services provide access to vehicles without necessarily needing to own them:

“We are offering the shared car service. It's our main focus, simply. It's the most important thing for us. Indeed, for us the most important thing isn't the car. We couldn't do without it, certainly. But our real gift to the consumer is making cars available for them. That's what it’s really about, on top of the flexibility this allows for”.

One of the main selling points in the P2P segment is the opportunity to either avoid or reduce the costs of vehicle ownership by transforming vehicles into money-generating assets. In addition, orchestrators seek to differentiate themselves from integrators by focusing on the increased level of flexibility that P2P sharing offers:

“...about what kind of additional value you get from our service compared to traditional car rental companies...We are able to offer cars in all price ranges, and it's left to the consumer to make the decisions about what kind of car he or she is looking for. And a lot of people have evidently considered your car totally sufficient”.

One other difference between orchestrators and integrators is that the level and quality of the service in P2P segments relies heavily on the engagement of vehicle owners and users. For example, whilst integrators can provide immediate accessibility to their fleet via the booking system (depending on availability at any given
moment), orchestrators are in some instances hampered by the response times of vehicle owners. One way to manage this limitation is for orchestrators to allow for user profiles which, among other things, state average response times from vehicle owners. User profiles are an instantiation of another major difference between integrators and P2P orchestrators. The former maintain rather loose ties with their customers by, for example, garnering feedback through electronic surveys. By contrast, orchestrators in the P2P segment have much closer ties with their users via frequent face-to-face meetings, telephone conversations and focus groups. The main reason for this is again that orchestrators are more reliant on private individuals to ensure that their services function, and because trust and social capital among vehicle owners and users is also critical. Without this, owners would be more reluctant to rent out their vehicles and both owners and users would be more reluctant to share rides. Hence several orchestrators request that owners and users publish profiles of themselves, complete with a picture and a personal description in a transparent fashion that allows others to make their own judgements regarding their willingness to share:

“…there are people who are not open about who they are. People who either have a mysterious picture of themselves, write very little, write poorly, or just show very few signs of general IQ and social ability. That would never be good. If there’s something strange in your text or the picture or the information that you send, you will always be declined. Yet if people are open they will always get what the ask for”.

Moreover, orchestrators do not just rely on trust and social capital; they actively promote and support it. This is particularly the case in the P2P ridesharing segment, as people often choose to share rides for reasons other than cost saving, such as the experience of travelling with a like-minded person during an intercity trip:

“…if you’re two single people and you end up in a car and you have a nice experience, it’s a great arena for casual discussion, because the discussion is just part of … it’s not the activity, it’s just there if you want it. We know that quite a few have romantic relationships through our service, and friends, people getting jobs, all these things. So yeah, there’s a lot of stories there, a lot of interaction…”.

One orchestrator has uniquely focused on the creation of trust and social capital by adopting an entirely different approach to commercial orchestrators, in that it describes itself as an ‘idea’ and a ‘movement’. In this arrangement, the orchestrator facilitates P2P ride sharing among groups of friends via social media outlets, taking no provisional fee for these activities. The main idea behind this movement, which is also environmentally motivated, is that friends can share the costs of trips evenly whilst contributing to a healthy civil society that is based on deep trust among peers.

Similar to integrators, orchestrators are actively experimenting with different elements of their business models. In some instances this includes the introduction of new value propositions that expand on their initial offering (e.g. P2P car sharing orchestrators diversifying into P2P ride sharing and vice versa, or by offering vehicle leasing services as part of an overall sharing package) and in other instances orchestrators focus on scaling their business models by entering into new partnerships with municipalities, businesses, property owners and housing companies that aim to reduce their own transport costs and environmental impacts by better utilising their own (or others’) vehicles. In one case, an orchestrator has partnered with a traditional car rental company to return vehicles deposited in different cities to their home stations, allowing for zero-cost P2P ride sharing. Some orchestrators are also involved in trials of digital keys. Here the rationale is the same as that of integrators, where digitalisation is seen as a key enabler of improved accessibility and flexibility. However, BMI in the P2P segment is hampered by a lack of clarity regarding taxable incomes. The Finnish transportation code, for instance, requires adjustments to clarify the levels of taxable income from P2P car
sharing. At present a €10,000 per year threshold is being discussed, but discussions are complicated by the perceived risk of Uber-like services to the traditional taxi industry.

A further focal point for BMI, which applies also to both integrators and orchestrators, is to establish partnerships with MaaS operators. The latter also function as orchestrators given that MaaS is dependent on an ecosystem of transport service providers. Partnerships are thus fundamental to its success. Several integrators and orchestrators have entered into partnerships with MaaS operators and are thus active in their experimental pilots and field tests, and one Finnish integrator is a partner in Finland’s most prominent MaaS scheme. In the Nordic region, MaaS is dependent on public transport as “the backbone of the service”, and thus requires collaboration from public transport operators (PTOs). Without a well-functioning and comprehensive public transport system, it would be difficult to develop business models that offer an affordable alternative to private car ownership. However, one key sticking point is that PTOs have historically been reluctant to allow third-party resales of tickets by MaaS operators. Partial resolutions to the problem have been implemented or are underway in both Finland and Sweden.

At present, the business model for MaaS is not complete. The overall value proposition is at a conceptual stage, in that it focuses on the combination of different transport services as described previously. In practice, however, the number of transport service providers will likely increase in the future as MaaS attracts increasing numbers of users, and operators are experimenting with the inclusion of a broader range of taxi operators, car rental services, car sharing organisations and so on. The overall utility of the MaaS concept is outlined as follows:

“It's not something where we want price to be our competitive advantage... It’s actually the ease of use... that it’s more convenient...and you can get all the tickets. You can get the public transportation, the taxi and the rental car, all in the same app, so you don’t have to go to many different sites or different apps. You can get it in the same place, together with routes based on where you are, and it makes the trip as convenient as possible. The freedom to choose and the ease of use is, those are the competitive advantages we have...We don’t want to be someone who sells, or a ticket aggregator, that’s not our business”.

The main reason for providing ease of use is to grant users with the accessibility required to perceive MaaS as a genuine alternative to private car ownership:

“To us, the most important thing is that if we are trying to promise users freedom, and if they are most of all trying to achieve a situation where we could be a good option instead of a private car, then of course it has to be as accessible and as easy to own a private car”.

MaaS can be viewed as a further facilitator of car sharing, in that providing access to integrators’ business models is key to convincing private car owners to adopt the service. In addition to the field tests and pilots described above, MaaS operators are experimenting with the inclusion of features within smartphone applications that allow users to compare their existing transportation costs with those of adopting a MaaS service. The feature allows users to enter their car registration number and calculates their transport costs based on the vehicle model and other data (e.g. kilometres driven per month).

Geographically, orchestrators as a whole focus at least initially on urban areas, for similar reasons as integrators. Further, some orchestrators argued that urbanites are more likely to adopt their services:

“Urban people are the ones who are most likely to be into our kind of solution. Like an app-based mobility solution, they are urban phenomena... Yeah, reading the right sort of media. Following the correct influencers. We have a lot of users who are very good at attracting new users, because they tell stories about us in social
media, they tell stories on the lunch table in the office, and the stories are generally “I’m doing something green, I’m doing something social”, or “I’m doing this smart, new app-based thing”. All of which are sort of arguably urban characteristics”.

However, several orchestrators in the P2P segment facilitate intercity ride sharing, whereby peers share longer trips for economical, environmental and/or social reasons (i.e. they prefer the company of a peer). Until now, ride sharing has proved to be more suited to longer trips rather than urban travel, although one Danish respondent commented that digitalisation can play a significant role in encouraging ride sharing for shorter trips, in that it can become more “real time”. Others are increasingly focused on commuting via partnerships with municipalities, and are thus active in linking cities and towns to their suburbs. Further, one P2P orchestrator is currently engaged in a pilot in Lapland, which aims to disprove the myth that sharing is an urban phenomenon by experimenting with the concept in rural areas: “If it works in Lapland, it works anywhere”. In Sweden, one P2P orchestrator with around 70,000 members has already been successful in facilitating ride-sharing in several rural areas. MaaS operators have a similar initial focus on urban areas, but focus instead on city regions to include suburban travel and commuting. This is partly due to the regional coverage of PTOs, which easily allows MaaS operators to have a similar focus. It is also partly a result of pressures from municipalities and local PTOs, who wish to improve regional (and not just inner city) accessibility via MaaS. Notwithstanding, in Finland a pilot is currently underway to test MaaS in a ski-resort (Ylläs), again giving credence to the notion that rural car sharing may be feasible. In Finland, the focus on new mobility services in less populated areas is in part driven by municipalities, who must find more cost-efficient ways of providing transport given the low utilisation of public transport on certain routes. Car and ride sharing, as part of intermodal schemes, are being tested as lower-cost alternatives.

Both commercial P2P orchestrators and MaaS operators have pricing models that operate on similar principles. In the P2P segment, orchestrators charge a provisional fee for every car and ride sharing transaction. Some P2P orchestrators, particularly those driven by ideological reasons (i.e. the opportunity to facilitate a sustainable civil society movement based on trust and sharing) charge no fee. MaaS operators offer different packages to users, with different levels of coverage at fixed monthly fees (although variable rates apply to pay-as-you-go subscription models). This pricing model, whereby transport costs are assimilated into a single monthly fee, have led one MaaS operator has marketed itself as “the Netflix of transportation”. Similar to commercial P2P orchestrators, MaaS operators generate revenues by charging provisional fees within each subscription.

and Norway has a similarly aged fleet. Orchestrators’ lack of discretion in renewing the vehicles in their fleets means that they cannot influence the deployment of new vehicle technologies such as EVs and autonomous vehicles in the same way that integrators can. Rather, orchestrators argue that technological renewal is the responsibility of private vehicle owners, which respond to market prices and the incentives created via public policy:

“In my mind, that’s the consumer responsibility, and that’s wherever the tastes of the consumers go. Both the people who ultimately buy or lease a car that they choose to rent out, but also which cars are favourable to rent on our platform. Norway is a really good example, because there you have clear incentives for acquiring an electrical vehicle, and definitely for driving around in one. So if you’re renting a car in Oslo, because you want to go to IKEA, and you want to go to the ski jump, and you want to take a trip to the beach, you want to be in an electrical vehicle, because you don’t have to pay any toll fees, and you can just park…everywhere. We have very little that we could do to shape those drivers...we cannot be a driver of those decisions. So we, as well as the private consumer, are shaped by the political environment and incentives. We take a very limited role in that sense. We have to play by the local market conditions; we are dependent on there being
clear political direction in terms of climate cars or sharing cars, and making that, in itself, lucrative for people. Because they ultimately are the...we were just a provider of the meeting place”

As regards to political actions that can help orchestrators scale their business models, some orchestrators argued in a similar fashion to integrators that rules regarding taxation and VAT must be clarified and equalised between different types of car sharing services. However, it was mainly MaaS operators, not P2P orchestrators, that argued for this due to the fact that they play an orchestrating role in bringing different transport service providers together in order to deliver their service. Hence their job is made easier if suppliers play by the same rules regarding VAT. In terms of taxation, MaaS operators argued that there is a need to introduce new taxation laws regarding work bonuses for business users. At present, there are taxation laws for company cars, but, given its novelty, there is no legislation for MaaS. Work is underway in Finland to rectify this problem.

Further, and similar to integrators, P2P orchestrators (particularly those involved in ride sharing) argued that governments should implement exemptions from congestion charges and parking fees given the sustainable aspects of using their services. One orchestrator argued that policymakers should focus on the creation of ride-share lanes alongside park and ride schemes that link commuting to P2P sharing. This would allow cars that are parked during working hours become available to others for short-term rentals. Another orchestrator argued that car sharing should be recognised for its potential to reduce CO$_2$ emissions, and thus be treated in a similar fashion to other mitigative measures in climate policies. Finally, orchestrators argued that governments and municipalities should assist in raising awareness for car sharing via information campaigns.

4. Discussion and implications for governance

Our findings suggest that different types of car sharing business models have different types of utilities in reducing CO$_2$ emissions from transport. Integrators, which primarily serve the B2C and B2B segments, operate business models that appear to be viable in urban centres and surrounding suburbs, where population densities allow for profitability. The main reason for this is that integrators own the vehicles in their fleets (as shown by the vertical axis in figure 1), and thus require a higher utilisation of individual vehicles. In contrast, orchestrators charge provisional fees to rentals of privately-owned assets and are thus less concerned with the level of vehicle utilisation. Rather, profitability depends on a large customer base where private vehicle owners match the needs of users. These differences have implications for the technological renewal of the vehicle fleet. Integrators typically strive for a modern fleet based on rapid renewal, whereas orchestrators have no discretion over the types of vehicles that are shared between peers. However, orchestrators are better placed to access areas with lower population densities, and several organisations have succeeded in (or are currently experimenting with) facilitating rural and intercity travel. The implications are that the geographical scaling of shared car travel relies on both integrators’ and orchestrators’ success in convincing users in the B2C, B2B and P2P segments to adopt replace private vehicle ownership with shared mobility. These applications of car sharing business models are summarised in figure 1.
Our study shows that both integrators and orchestrators are actively experimenting with different elements of their business models as a means to attract larger numbers of users. In practice this means focusing on incremental BMIs that serve to improve the flexibility, convenience, accessibility and affordability of car sharing such that business models scale (i.e. diffuse to new geographical areas following adoption by increasing numbers of users). One key focal point for BMI is the further deployment of digital technologies (digital keys) to enable better accessibility in each of the B2C, B2B and P2P segments. Digital keys may potentially give rise to new forms of car sharing whereby peers pool their own vehicles within integrators’ fleets for use by business and private users (referring to the lower right quadrant in figure 1). The advent of digital keys means that some integrators will likely adopt the orchestrator role. Moreover, car sharing organisations, especially integrators, show a definitive interest in electrifying their fleets, and both integrators and orchestrators argue that they are well placed to appropriate the benefits of autonomous vehicles. Tests and pilots are currently underway in both of these technological fields, and several organisations have already made headway in the deployment of EVs.

Given the range of innovative experiments in this field, one may argue that of the three processes that occur within niches, car sharing organisations are successful in terms of experimentation and learning. Learning in this case refers to the ability of car sharing organisations to develop new ways to match user needs and expectations via new value propositions, but it also refers to the propensity among users to modify their transport behaviour and travel patterns. Car sharing is not the same as car ownership, especially since the dominant station-based model implies that users must travel to gain access to cars. Whilst car sharing is a growing phenomenon, it remains to be seen whether the necessary changes in attitudes and behaviour will occur. To this end, pilots and tests of new concepts are useful, and it is essential that they are designed on a low-cost and low-risk basis (Sochor et al., 2016). Car sharing organisations can assist in creating such conditions by, for instance, waiving subscription fees, but it remains to be seen whether this is sufficient to persuade car owners given the sunk costs of vehicle ownership.

Our findings demonstrate that the other niche-level processes (the articulation and adjustment of expectations or visions; and the creation of social networks and the enrolment of actors) are not as strongly supported in the field of car sharing. The main reason for this appears to be a persistent fragmentation that has been observed in other parts of the transport system (Banister, 2008; Jones, 2012; Miciukiewicz and Vigar, 2012; Schwanen...
et al., 2011). That is, both integrators and orchestrators compete more than they collaborate, and there is a lack of a clear and robust vision for car sharing in the Nordics, despite its linkages to technological renewal in particular and transport system sustainability more generally. In short, car sharing organisations appear to have not yet successfully created the social networks that are necessary to bring about radical change. One exception is related to MaaS, which is a radically new concept that necessitates that creation of new networks and partnerships with public and private sector actors, both nationally and internationally (Sarasini et al., 2016b). Our study also demonstrates that both integrators and orchestrators are increasingly interested in the MaaS concept, and several car sharing organisations have already entered into MaaS partnerships – especially in Finland.

Based on these observations, it is possible to trace three potential pathways regarding the future of the road transport system (figure 2). The first is the traditional, tried, tested (and failed?) technological substitution pathway, where a focus on the greening of cars obscures the need to modify transport practices and behaviour (Kemp et al., 2012). The second (shared mobility) is an extension of the current trend towards car and ride sharing, with the caveat that initiatives and schemes remain fragmented, such that integrators continue to compete rather than collaborate, failing to create the right conditions to transform the existing regime. The third pathway, entitled ‘integrated mobility’, is traceable from the current focus on intermodal mobility services (Parkhurst et al., 2012), assuming that the current attention given to MaaS is not part of a hype-disappointment cycle (Verbong et al., 2008).

It is important to note that these pathways are not separate, in that the servitisation of transport in the shared and integrated mobility pathways can create incentives for more rapid technological renewal of vehicle fleets. In addition, product-servitisation creates incentives for material recirculation, akin to the principles of the circular economy (Tukker, 2015)Product Service Systems (PSS, and intermodal mobility services have been shown to encourage shifts among users towards more sustainable transport modes such as cycling and walking (Sochor et al., 2016; Strömberg et al., 2016). Further, the integration of telecommunications, energy services and transport via intermodal mobility services in the mid to long term is seen by some as a significant innovation opportunity (Sarasini et al., 2016a, 2016b; Spiekermann et al., 2014).

![Figure 2: Three pathways towards a sustainable Nordic road transport system.](image)
The governance of such a transition is not easy to understand. Our study shows that at present, several actors from within and outside the transport regime are experimenting with different models of sharing in response to a multitude of landscape-level drivers and pressures (digitalisation, urbanisation, the persistence of sustainability problems, accessibility, etc.). Based on this, it is not entirely clear how the shared and integrated mobility pathways outlined above should be categorised. On the one hand, they may be seen as *purposive transitions* in that both state and non-state actors are actively supporting niche and regime-level activities that may bring about a transformation (Geels and Kemp, 2006). However, the integrated pathway may be better described using the idiom *reconfiguration*, since a transition to intermodal mobility systems focuses on the (re)alignment of regime actors’ business models and positions in the value chain, where a new entrant serves to orchestrate the MaaS system (Geels and Kemp, 2007; see also Geels 2006a). Regardless, we propose that in addition to resolving the obstacles to BMI outlined in section three, practitioners and policymakers should focus on articulating visions and expectations that serve to maximise the potentials outlined above. In the Nordic region, such discussions are already underway, but have not yet yielded a truly overarching vision of a sustainable transition in road transport. It is with these potentials in mind that we present the three pathways, which are intended as a contribution to ongoing discussions.

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**References**


**MaaS in Tourism Along Danube**

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**Executive summary**

The Danube region is one of the most promising tourism destinations in Europe, with more than 100 million overnight stays per year in registered facilities (Eurostat). Most of the trips to the Danube and within the Danube region are carried out by car. The dominance of car usage is the reason for the unsustainable development of the transport sector, being a main source of GHG emissions, pollutants and noise. Hence European policies call for a decarbonisation of transport promoting a mobility transition.

For the development of sustainable mobility in tourism, appropriate mobility services along the whole travel chain are needed – in and between the destinations. The current situation along the Danube shows another picture. The quality of public transport services as well as the coordination with other mobility services is still weak especially in the lower sections of the Danube. Integrated multimodal transport services and integrated information allowing people to select the most suitable mode of transport and/or possibilities to combine the existing mobility services along the travel chain are missing in most of the regions.

Getting understandable and comprehensive information on possibilities to travel the Danube regions with sustainable means of transport is still not easy. Existing transnational tourism information platforms (e.g. Danube.travel) are mainly focusing on the description of touristic attractions. Platforms providing information about existing sustainable mobility services are mostly limited to the national territory – information is provided in national language. At the destination it is even harder to find people that can know about existing bus services, train timetables, etc. Different levels of know-how for the development and implementation of sustainable mobility services as well as a lack of cooperation between the relevant stakeholders – within the transport sector and between the transport and the tourism sector – are major challenges for bringing forward the concept of sustainable mobility. The project [Transdanube.Pearls](#) aims at overcoming these deficiencies, starting with building a sound basis for cooperation and increasing the capacity to promote and further develop improvements in sustainable transport services and information for visitors, which will provide added value for the inhabitants as well.

**Introduction**

The Danube region is one of the most promising tourism destinations in Europe, with more than 100 million overnight stays per year in registered facilities (Eurostat). Most of the trips to the Danube and within the Danube region are carried out by car. The dominance of car usage is the reason for the unsustainable development of the transport sector, being a main source of GHG emissions, pollutants and noise. Hence European policies call for a decarbonisation of transport promoting a mobility transition.

The paper presents the main innovation of a new project funded by the Danube Transnational Program (DTP) 2014-2020 the concept of a Sustainable Regional Tourism and Mobility Plan. Built on the existing SUMP-concept, the new planning methodology goes beyond the city/town scope by unifying several settlements along
Danube having touristic potential by sustainable transport links thus providing a sustainable transportation along Danube for visitors and local population.

1. **Highlights of the TRANSDANUBE.pearls project**

The main objective of TRANSDANUBE.pearls is to contribute to the development of a Danube region, which provides socially fair, economically viable, environmentally friendly and health promoting mobility for visitors and inhabitants of the region by developing climate friendly, low-carbon and low-emission, multimodal and efficient transport systems and sustainable tourism services. By improving the possibilities to move along the Danube with environmentally friendly means of transport the project will counteract the ongoing popularity of private car usage and its negative impact on the environment. By better linking the different modes of transport the project will not only contribute to sustainable regional and local mobility but also support the connectivity between the regions, leading to a more balanced accessibility within the Danube regions.

Within the 2.5 years of implementation the project TRANSDANUBE.PEARLS funded by Danube Transnational Program, will establish a network of destinations committed to sustainable mobility in tourism—the “Transdanube.Pearls”. Being part of this network will increase the visibility of the participating destinations offering their visitors the unique possibility to travel the Danube with sustainable means of transport. On the other hand, the network will facilitate the cooperation of stakeholders from the mobility and tourism sector of different levels. Common standards and appropriate organizational structures secure the operation of the network beyond project lifetime.

2. **Partnership in TRANSDANUBE.Pearls**

The project partnership is building on the partnership of the previous SEE-project TRANSDSANUBE, led by the Environment Agency Austria. The positive experience from this project encouraged the LP to invite the majority of the partners to proceed with the work started in TRANSDANUBE. Additionally some new partners have been actively involved in order to close territorial gaps or to bring in necessary competences to successfully implement the project. The partnership is now covering eight countries along Danube resp. nine out of the 14 countries of the program area. The Danube Competence Center acting on the transitional level will strengthen the transnational approach of the project. The majority of partners are representing regions, respectively the regional authorities and development agencies, dealing with various topics like transport and economic development including tourism, all experienced in transnational projects and committed to sustainable mobility. The partners have identified additional stakeholders necessary for a successful project implementation, which will be involved during the whole project lifetime. Associated partners (ASPs) from the national and regional level will provide the necessary political back up and possible financing.

3. **SRTMP Concept**

The ambitious goals of the project will be achieved by introducing its main innovation – the Sustainable Regional Tourism and Mobility Plan (SRTMP).

Possibilities to travel along the Danube with sustainable means of transport are still weak. In order to provide visitors with services to move between the Danube regions the harmonization of existing services has to be optimized. By improving the possibilities to easily change between existing public transport services and the
bicycle ((by using bike carriages on trains and busses) it will be possible to improve connectivity within the Danube region in general and especially between the Transdanube.Pearls. For improving the connectivity and accessibility within the Danube regions it is necessary to link existing train and bus services with improved services on the last mile (flexible public transport and cycling). By closing the gaps along the multimodal travel chain, new mobility services will additionally improve the transport links between urban and rural areas. The development of mobility services will be carried out in a coordinated manner supported by transnational implementation guidelines jointly elaborated by the partners.

The definition of a **Pearl** is:

A Pearl is member of the network of Transdanube.Pearls, which will be set up during the projects realization, and needs to meet the defined common standards especially the commitment to implement the concept of sustainable mobility in tourism. A Pearl can be a single municipality/village or a region/destination (consisting of several municipalities) committed to sustainable mobility in tourism.

The definition of a **SRTMP** is:

SRTMP is a strategic plan designed to satisfy the mobility needs of visitors and local population in the pearls for a better quality of life. It builds on existing transport and tourism planning practices and takes due consideration of integration, participation, and evaluation principles. Compared to a SUMP, SRTMPs have a strong focus on the vertical (municipality, region, Danube Region) and horizontal (transport & tourism) integration.

CSDCS together with the LP elaborated the SRTMP Guidelines where four main stages are defined:

1. **PREPARATION PHASE: PREPARE WELL BY UNDERSTANDING YOUR REGION**
2. **CREATE COMMON GROUND AND VISION**
3. **ELABORATING THE SRTMP BY USING THE OUTCOMES**
4. **ADOPTION AND IMPLEMENTATION OF SRTMP**

The above mentioned stages are closely interlinked with other activities in the project. There is an activity dealing with the preparation of the regions (State of the Art Analysis). The goal setting has already been done by adopting the common vision of the project. More detailed goals will be defined in the common standards developing. Based on SRTMPs the partners will set the next step for implementing new/improved mobility services. In many cases partners will not start from scratch but base their work on existing studies. Taking into account the requirements of suitable funding schemes from the very beginning, the partners will elaborate all data and information necessary to start negotiations with (co-)financing institutions. By testing selected mobility services, the partners will demonstrate the feasibility and the benefits of sustainable mobility services for the visitors as well as the added value for the inhabitants.
4. Conclusion

The SRTMP will be presented to regional & local authorities in order to integrate them in existing policy documents and strategies and to inaugurate some funding initiatives. They will also be the guidelines for the implementation of measures necessary to fulfill the criteria defined in the common standards beyond project lifetime. The involvement of the relevant national authorities will facilitate the adaptation of framework conditions supporting the implementation of sustainable mobility offers in the national transport and tourism policies/strategies.
Micro transit and MaaS
An Optimization Based Analysis of a Micro Transportation Service

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Purpose In most rural areas high rates of motorized individual transport are observed since only few public transportation services are available. At the same time, progressing urbanization forces an increasing number of people to commute between rural and urban areas where convenient public transportation services are available. Micro transportation services operate a fleet of vehicles in order to bridge this gap by transporting people between rural places and public transportation hubs such as train stations. In comparison to taxis, their fees are quite low. However, multiple customers are driven in the same car at once, and demands must be pre-announced. Communes might be willing to subsidize such services since they profit from affordable public transport, decreased local emissions, and avoided car-induced traffic in neighboring urban centers.

This study investigates measures for improving operating cost and user convenience of such services based on methods stemming from operations research. Trade-offs between customer travel times and operating costs are analyzed and optimized for a real-world setting.

Methodology We analyze a use case based on real-world data stemming from a transportation company operating in the district of Korneuburg, Austria (near Vienna). Usually, trip requests are known a day before. So, tours can be planned beforehand taking operating costs and user convenience into account. Allowed detour durations and departure time deviations are measures for user convenience. When relaxed, they provide flexibility for service providers to combine user trips into common tours in order to increase vehicle capacity utilization. These trade-offs between convenience and costs are analyzed by computing and comparing different plans determining vehicle tours. This comparison is implemented based on algorithms for the well-known pick-up and delivery (or dial-a-ride) vehicle routing problem with time windows.

Mathematical Model We tackle the optimization problem by formulating a mathematical model that can be solved using integer linear programming solvers. At the same time this provides a formal problem description. For are given a set of nodes $V = B \cup P \cup D$ where $B$ denotes depot nodes, $P$ denotes pickup nodes, and $D$ denotes delivery nodes the complete graph $G = (V, E)$ describes connections in an underlying road network. The travel time between two nodes $i, j \in V$ is given by $t_{i,j} \in \mathbb{R}$. For a pickup (delivery) node $i \in V$ its corresponding delivery (pickup) node is denoted by $v_i \in V$. The fleet of vehicles $K = K_s \cup K_f$ is composed of standby vehicles $K_s$ and flexible vehicles $K_f$ which differ in their...
usage costs. For each vehicle $k \in K$, we are given its start location $s_k \in B$ and end location $e_k \in B$, and its capacity $C_k \in \mathbb{N}$. Costs differ for loaded and unloaded vehicles, so costs per distance for loaded vehicles are denoted by $c_{s}^L \in \mathbb{R}^+$ and $c_{f}^L \in \mathbb{R}^+$, and for empty vehicles by $c_{s}^E \in \mathbb{R}^+$ and $c_{f}^E \in \mathbb{R}^+$, with $c_{s}^E \leq c_{s}^L$ and $c_{f}^E \leq c_{f}^L$. For each node $i \in V$, we are given a time window $[a_i, b_i]$ and a service duration $s_i \in \mathbb{R}^+$ reflecting the desired departure time of passengers and a travel duration which include a buffer time that is varied within the numerical experiments. For each node $i \in V$, its load $l_i \in \mathbb{N}$ specifies the number of passengers that want to get in ($l_i > 0$) or out ($l_i < 0$) at $i$. A sufficiently large constant $M \in \mathbb{R}$ is introduced for modeling purposes. The following integer linear programming model is an adaption of the formulation given in [1] to the problem at hand. It uses the following variables. Binary variables $x_{i,j}^k$ describe if an arc $(i, j) \in E$ is used by the vehicle $k \in K$. Binary variables $x_{i,j}^{k,L}$ specify if an arc $(i, j) \in E$ is used by a loaded vehicle $k \in K$. Binary variables $x_{i,j}^{k,E}$ specify if an arc $(i, j) \in E$ is used by an empty vehicle $k \in K$. Variables $T_i \in \mathbb{R}$ determine for nodes $i \in N$ the start time of the service. Variables $L_i \in \mathbb{N}$ determine for nodes $i \in N$ the load (in number of passengers) when a vehicles leaves that node.

\[
\begin{align*}
\min & \quad \sum_{(i,j) \in E} \left( \sum_{k \in K} x_{i,j}^{k,L} c_{s}^L s_i + x_{i,j}^{k,E} c_{s}^E s_i + \sum_{k \in K} x_{i,j}^{k,L} c_{f}^L f_j + x_{i,j}^{k,E} c_{f}^E f_j \right) \\
\text{s.t.} & \quad \sum_{k \in K} x_{i,j}^k = 1 \quad \forall i \in P \tag{2} \\
& \quad \sum_{j \in N} x_{i,j}^k - \sum_{j \in N} x_{j,v_i}^k = 0 \quad \forall k \in K \quad \forall i \in P \tag{3} \\
& \quad \sum_{i \in P \cup \{e_k\}} x_{s_k,i}^k = 1 \quad \forall k \in K \tag{4} \\
& \quad \sum_{i \in N} x_{i,t_i}^k - \sum_{i \in N} x_{j,v_i}^k = 0 \quad \forall k \in K \quad \forall j \in V \tag{5} \\
& \quad \sum_{i \in D \cup \{s_k\}} x_{i,e_k}^k = 1 \quad \forall k \in K \tag{6} \\
& \quad T_i + s_i + t_{i,j} \leq T_j + M \cdot (1 - x_{i,j}^k) \quad \forall k \in K \quad \forall (i, j) \in E \tag{7} \\
& \quad a_i \leq T_i \leq b_i \quad \forall i \in V \tag{8} \\
& \quad S_i \leq S_{v_i} \quad \forall i \in P \tag{9} \\
& \quad L_j \leq L_i + l_j + M \cdot (1 - x_{i,j}^k) \quad \forall k \in K \quad \forall (i, j) \in E \tag{10} \\
& \quad L_i = 0 \quad \forall i \in B \tag{11} \\
& \quad x_{i,j}^{k,E} + x_{i,j}^{k,L} = x_{i,j}^k \quad \forall k \in K, (i, j) \in E \tag{12} \\
& \quad \sum_{j \in V} x_{i,j}^{k,L} \geq \frac{L_i}{C_k} \quad \forall k \in K, i \in V \tag{13}
\end{align*}
\]
The objective function (1) reflects the aim of minimizing costs which depend on the load and type of the vehicle. Constraints (2) to (11) are taken from [1] for modeling classical dial-a-ride constraints. In addition, constraints (12) and (13) are introduced for distinguishing loaded from empty vehicles. The general purpose mixed integer linear programming solver IBM ILOG CPLEX Optimizer, version 12.6.2, is used. For resolving larger instances, a meta-heuristic approach based on a best insertion construction heuristic and a subsequent variable neighborhood descent is applied.

**Findings** We solve multiple problem instances with varying time windows, each modeling a different level of user convenience. For instances based on requests stemming from real-world data, results show that user trips can be combined without considerably deteriorating service quality. E.g., already allowing a few minutes of additional waiting time or detour yields cost improvements that depend on the number and distribution of requests per day. Results are compared with real-world GPS-traces recorded over a period of more than one year. Table 1 shows an excerpt of the first numerical results aggregated over 1-day instances with different sizes varying from less than 21 to up to 80 requests. Acceptable additional waiting times (tw) of 0, 5, 10, 30, and 60 minutes are tested and compared to the unbounded case (1440 minutes). Two key figures are compared: The average improvement of the operational costs for the different waiting times over the base case of 0 minutes ($\text{imp}^{\text{tw}}$) and the average improvement over the request assignment and order as given by the real world instances ($\text{impr}^{\text{rw}}$).

| tw[min] | $|P| \leq 20$ | $20 < |P| \leq 50$ | $|P| > 50$ | $|P| \leq 20$ | $20 < |P| \leq 50$ | $|P| > 50$ |
|---------|----------------|----------------|--------|----------------|----------------|--------|
| 0       | -              | -              | -      | -              | -              | -      |
| 5       | 0.78%          | 1.01%          | 3.44%  | 7.57%          | 21.77%         | 29.68% |
| 10      | 1.98%          | 1.53%          | 5.92%  | 11.93%         | 21.22%         | 29.12% |
| 30      | 4.01%          | 2.77%          | 7.01%  | 14.12%         | 25.38%         | 32.99% |
| 60      | 6.36%          | 6.31%          | 11.14% | 16.34%         | 30.55%         | 34.80% |
| 1440    | 16.73%         | 33.28%         | 38.36% | 30.24%         | 51.28%         | 56.58% |

The numerical results shown in Table 1 indicate an improvement potential at the cost of user convenience. If the number of requests is getting larger, the operational cost reduction increases to up to nearly 6% if the users are willing to accept waiting times of up to 10 minutes. The currently used real world solution, i.e., the assignment of orders to vehicles and the order of the visits, also show further improvement potential. Based on some assumptions, e.g., all orders of the day are known beforehand and a fixed fleet size, applying the optimization algorithms yields an improvement of up to 30% for larger instances when a time window of 10 minutes is assumed. For some instances it was even possible to find solutions effectively reducing the waiting time of the users (compared to real world solutions) and thereby increasing the user convenience while minimizing the costs at the same time. However, an assessment of the applicability of computed solutions in practical settings remains to be done.

**Implications** Operating micro transportation services in a cost efficient and user convenient manner is crucial for scaling up their application to further regions. Results based on real-world
data show that a decision support system directing the fleet of vehicles in a meaningful way can have crucial impact on the amount of sharing and pooling involved. In this sense, such services provide a link between areas with diverging public transportation offers that can be seen as an implementation of a mobility as a service concept supporting sustainable transportation, in particular for commuters.

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Why do people switch to a modern on-demand ride service based on sharing? Background and motivation of Kyyti Rideshare passengers in Finland

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New digitally ordered and managed mobility services enable people to meet their individual needs in a flexible manner which could reduce car-dependency and its adverse consequences such as emissions, congestion, reduction of livable urban space and high costs of mobility. To evaluate the impacts, we need to study the mobility behavior of the users of these new services. Understanding the users and their motivations is necessary also for the design of the services to meet the needs even better. We are just in the beginning of the mobility service revolution and still need to find out more deeply what is required from the services to replace the car ownership and use. This paper presents a first deep dive into the users of Kyyti Rideshare service, which was launched in March 2017 in Oulu, and in June in Turku and Tampere in Finland. The results show that a typical Kyyti user is a car owner in his 20's or 30's mixing different travel modes. There is a significant difference between weekly and less frequent Kyyti users. As the biggest impact on the mobility behavior and operational efficiency comes from the weekly use, the needs of these users should be the ultimate guideline for the service design, regardless that the user base growth comes from the occasional weekend users.

KEYWORDS ride sharing, micro-transit, customer segments, mobility behavior, mobility as a service

Kyyti Rideshare: on-demand rides designed for MaaS

Kyyti exists to make daily travel easy. It is an on-demand or micro-transit service that lies in between traditional taxi and public transport. Kyyti takes passengers from door to door (or address to address) like a taxi would, but it is much cheaper than a taxi because several passengers are matched into the same vehicle and ride. The final routes and timetables for the rides are created based on the chosen flexibility category by each passenger. The more flexible you are in travel and waiting times the cheaper your ride is. Kyyti can be ordered both immediately and beforehand without extra booking fees. Kyyti is ordered by a mobile application (until so far called Tuup) that allows users to compare different Kyyti service levels as well as other mobility options.

The vision of Kyyti is to improve the efficiency of transport systems, especially in areas where traditional fixed route busses cannot offer sufficient service level without substantial public financing. Also, Kyyti can solve the first and last mile problem by connecting people to public transit trunk routes in ways which will remove the hassle of planning the travel.

Research objectives, methods, and the structure of the paper

The objectives of the Kyyti customer research was to find out: 1) what kind of people use Kyyti and how their usage patterns differ from each other, 2) for what trip purposes is Kyyti used for, 3) which travel modes Kyyti replaces, and 4) why did the users chose Kyyti instead of the alternative travel mode? These questions are also discussed in this paper.
During spring, summer, and autumn 2017 Kyyti conducted several user interviews, a user feedback workshop, and a user survey. Oulu users were interviewed and surveyed in June and Turku and Tampere users in September. Around 20 persons participated the workshop and the interviews. Half of them were deep interviewed. The interviewees were a diverse group in regards of their age, socioeconomic status and in the way, they had adapted Kyyti as a means of transportation. Based on the interviews a preliminary segmentation of user profiles and motivations to use Kyyti was made as follows:

1. For the **weekend party users** Kyyti replaces mainly taxi use because it’s cheaper. The social element of ride sharing was considered as a bonus offering nice surprises and maybe even new acquaintances.
2. For the **car-free singles or couples** Kyyti replaces slow or non-existing public transport or walking and/or cycling in bad weather. Kyyti also enables them to be independent as they don’t have to ask rides from their friends and relatives. They use Kyyti for various purposes on a weekly basis.
3. For the ones using **Kyyti for business travel or getting to the stations and ports** it is valuable to be able to pre-book a ride. Also, easy payments are appreciated.
4. The families or couples using **Kyyti as a second car** (or even the first car) do not want to invest extra on cars. In addition to leisure trips, Kyyti is used occasionally for commuting and personal business trips, when spouses would need a car at the same time.

The interview findings guided the design of the quantitative survey. The survey was sent only to users with ordered Kyyti trips. Survey got altogether 841 responses of which 497 are using Kyyti mainly in Oulu, 137 in Tampere and 207 in Turku. The response rate was 19 %.

**Kyyti users are younger than the population on average**

The users were classified into three categories according to their frequency of Kyyti use stated in the survey: 1) the **weekly users** stated using Kyyti at least once a week for at least one trip purpose (8 % of the respondents), 2) **monthly users** stated using Kyyti 1-3 times per month for at least one trip purpose (46 % of the respondents), and 3) **infrequent users** stated using Kyyti less than once a month (46 % of the respondents). As the service is still new and attracting “beginners” all the time, the minor share of weekly users is natural. However, we are especially interested in these frequent users, as it is the group that we would like to scale, both in order to have efficient fleet operations and in order to have bigger impact on mobility behavior.

Figure 1 shows that most of the respondents were 18 to 29 years old. There were also slightly more men and only 25 % had a family with children, which is less than for the Finnish population on average of 39 %. (Statistics Finland 2017a). The share of respondents in working life was about the same as among the Kyyti users (66 %) as among the Finnish population at large (72 %) (Statistics Finland 2017b).
The share of weekly users was a bit higher among younger generations and males. Also, the age groups not in working life or studying (i.e. on a pension, unemployed or parental vacation) had a higher share of weekly users. This could be due to more flexible schedules allowed by these people.

A typical Kyyti user has at least one car in the household and is also the main user of it

The share of people living in car-free households is larger among Kyyti users (34 %) than for the population in Oulu, Tampere, and Turku on average (26 %). However, the share of car-free households among Kyyti users is lower than we expected. It is especially interesting, that as the Figure 2 shows, the usage share by those who are the main users of a car in the household, is highest. A typical Kyyti user thus has at least one car in the household and is also the main user of it. This means that Kyyti has succeeded to attract people who are used to driving their own car. It is surprising that those, who do have a car in the household but are not the main user of it, are not represented more among Kyyti users. Could it be because they have settled to public transport, cycling and walking and don’t require so much as the ones used to driving? For the main car users, it is easier to jump into Kyyti than to take a bus. However, the share of weekly users is a bit larger among the car-free users and the non-main-car-users (Figure 3). Interestingly, the share of infrequent Kyyti users (less than once a month) is the largest among car-free households.

Kyyti user's repertoire of mobility is more varied than for the population on average

The respondents were asked how often they utilized different travel modes before they started using Kyyti. Based on this question the respondents were categorized into five segments that describe their personal repertoire of travel modes (segmentation was created by Voltti and Karasmaa in 2006):

- heavy car users (uses other travel modes nearly never)
- car users (uses mainly car, but occasionally other modes as well)
- people who mix all modes of travel (including both summer/winter exchange)
- regular customers of public transport (usually have public transport monthly tickets)
- people who prefer walking or cycling

Among the Kyyti users the share of travel mode mixers (34 %) is significantly larger than among the
population of the three cities on average (13 % in 2005) (Figure 4). Also, the share of regular public transport users is higher among Kyyti users. On the contrary, the share of walkers and cyclists is dramatically lower among Kyyti users. But, the share of heavy car users is not so much lower among Kyyti users. This means that Kyyti users are not so polarized into either car or public transport users, but majority use the most suitable alternative depending on the situation.

Furthermore, as shown in Figure 5, the travel mode mixers had highest share of weekly users. Regular public transport users and walkers and cyclists were least active in their Kyyti use.

These results correlate with the previous observation that the majority of Kyyti users are main users of a car in the household, and that Kyyti is especially attractive for those who appreciate the benefits of car travel over public transport or walking/cycling. This means that over time Kyyti might eventually reduce the car ownership of these people if they learn to trust the service increasingly.

Kyyti is mainly used for leisure trips but work-related purposes are important among weekly users

Figure 6 shows how common it is to use Kyyti for different trip purposes. Note that the figure shows only the share of respondents; not the share of trips. Some of the trip purposes occur more frequently than others. The leisure trips both on weekends and on weekdays are clearly most common. However, the difference between weekend leisure use and other use is not so strong among weekly users. 36–45 % of the weekly users state using Kyyti for going to work or school and on company as well as personal business trips, whereas for all Kyyti users these shares are only 12–15 %.

Using Kyyti for getting to or from the stations (airport, railway- and bus stations) is very common both among weekly as well as all users (38–45 % of the respondents). This is an indication that Kyyti can serve as the first and last mile solution for public transport trunk routes.

When the different trip frequency categories are given weights, it is possible to estimate the distribution of trip purposes per person. As can be seen in Figure 7, the share of weekend leisure trips is only under 30 % for weekly users whereas for occasional users it is nearly 50 %. The share of work (or school) related travel...
on the other hand rises to 25% for weekly users while being only about 10% for the occasional users. This means that Kyyti can be especially valuable for employers, who are struggling with insufficient commuting options or want to reduce the car use and parking for business travel purposes. The trips of weekly users are also occurring more often on weekdays and congestion peak hours which feeds base traffic into Kyyti operations that then makes ride sharing more efficient and provides better availability to occasional users as well.

Figure 6. Use of Kyyti for different trip purposes (share of respondents)

Figure 7. Distribution of trip purposes per person: comparing a weekly (at least once a week) and an occasional (less than once a week) user
Kyyti replaces mostly taxi and public transport use; but the role of car gets more significant on everyday trips

Until now Kyyti has replaced mainly taxi use: on average 43% of respondents said they would have used taxi if Kyyti didn’t exist (Figure 8). Public transport was the second common alternative with 27% share on average. Even though majority of Kyyti users have cars, car would have been the alternative for Kyyti only for 14% on average. The average shares are resulting from the large share of weekend leisure trips where alcohol is usually hindering the car use.

However, for the work-related travel and personal business and regular hobby trips, the car would have been the option for around 20% of the respondents. This means that significant impact on car use reduction arises only when Kyyti use gets more common on daily basis as well. The replacement of car use might already be more common among weekly users, but it was not analyzed for this paper.

![Figure 8. Distribution of travel modes that Kyyti replaces (share of respondents for each trip purpose category)](image-url)

- Walking
- Cycling
- Public transport
- Taxi
- Private car (as a passenger)
- Private car (driving yourself)
- Would not have made these trips without Kyyti

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Walking</th>
<th>Public transport</th>
<th>Taxi</th>
<th>Private car (as a passenger)</th>
<th>Private car (driving yourself)</th>
<th>Would not have made these trips without Kyyti</th>
</tr>
</thead>
<tbody>
<tr>
<td>To work or school</td>
<td>33%</td>
<td>20%</td>
<td>6%</td>
<td>19%</td>
<td>19%</td>
<td>20%</td>
</tr>
<tr>
<td>Company business trips</td>
<td>33%</td>
<td>20%</td>
<td>6%</td>
<td>19%</td>
<td>19%</td>
<td>20%</td>
</tr>
<tr>
<td>To the grocery store</td>
<td>33%</td>
<td>20%</td>
<td>6%</td>
<td>19%</td>
<td>19%</td>
<td>20%</td>
</tr>
<tr>
<td>Other personal business trips</td>
<td>33%</td>
<td>20%</td>
<td>6%</td>
<td>19%</td>
<td>19%</td>
<td>20%</td>
</tr>
<tr>
<td>To hobbies that repeat regularly</td>
<td>33%</td>
<td>20%</td>
<td>6%</td>
<td>19%</td>
<td>19%</td>
<td>20%</td>
</tr>
<tr>
<td>Leisure activities during the week</td>
<td>33%</td>
<td>20%</td>
<td>6%</td>
<td>19%</td>
<td>19%</td>
<td>20%</td>
</tr>
<tr>
<td>Leisure activities during the weekend</td>
<td>33%</td>
<td>20%</td>
<td>6%</td>
<td>19%</td>
<td>19%</td>
<td>20%</td>
</tr>
<tr>
<td>To or from the airport, railway station or a bus station</td>
<td>33%</td>
<td>20%</td>
<td>6%</td>
<td>19%</td>
<td>19%</td>
<td>20%</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>33%</td>
<td>20%</td>
<td>6%</td>
<td>19%</td>
<td>19%</td>
<td>20%</td>
</tr>
</tbody>
</table>
Affordable price and door-to-door travel are reasons to use Kyyti; pre-booking is important in travel chains

As seen in Figure 9, the most important motivations to choose Kyyti are the affordable price and the ability to get from door-to-door. Out of all trip purposes, on average 39% of participants valued the affordable price as their primary or secondary motivation. The ones using Kyyti for leisure trips during weekend valued affordability the most with 42% choosing this as their primary or secondary motivation. The third biggest motivation was the possibility to pre-book Kyyti.

The price was relatively least important on company business trips and on trips to or from the stations. On these trips, the role of pre-booking was the highest (13% and 20% of the respondents). Pre-booking usually comes with a higher price, but for Kyyti pre-booking reduces the price as it improves the possibilities to optimize the sharing and routes. This feature added to the capability to define the latest *arrival time* distinguishes Kyyti from many other ride sharing services.

**Figure 9. Reasons to use Kyyti on average and for 3 trip purposes**

<table>
<thead>
<tr>
<th>Reason</th>
<th>AVERAGE reason</th>
<th>Trips to or from the airport, railway- or a bus station.</th>
<th>Company business trips</th>
<th>Leisure activities during weekend</th>
</tr>
</thead>
<tbody>
<tr>
<td>I do not want to depend on friends/relatives transporting me</td>
<td>5%</td>
<td>4%</td>
<td>9%</td>
<td>6%</td>
</tr>
<tr>
<td>Paying the trip was convenient</td>
<td>9%</td>
<td>20%</td>
<td>13%</td>
<td>9%</td>
</tr>
<tr>
<td>I could plan and order Kyyti beforehand</td>
<td>3%</td>
<td>4%</td>
<td>3%</td>
<td>4%</td>
</tr>
<tr>
<td>The weather/road conditions were bad</td>
<td>16%</td>
<td>7%</td>
<td>6%</td>
<td>14%</td>
</tr>
<tr>
<td>I had a lot of things to carry</td>
<td>4%</td>
<td>3%</td>
<td>1%</td>
<td>16%</td>
</tr>
<tr>
<td>I was not in the mood for walking or cycling</td>
<td>39%</td>
<td>36%</td>
<td>29%</td>
<td>42%</td>
</tr>
<tr>
<td>The car I use was not available</td>
<td>4%</td>
<td>13%</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Kyyti fits my schedule better</td>
<td>7%</td>
<td>2%</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td>Kyyti was fast</td>
<td>4%</td>
<td>1%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Kyyti gets me from door to door</td>
<td>3%</td>
<td>4%</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Comfortable traveling</td>
<td>7%</td>
<td>2%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Affordable pricing</td>
<td>4%</td>
<td>4%</td>
<td>9%</td>
<td></td>
</tr>
</tbody>
</table>

Conclusions and further research needs

Many studies indicate that trouble-free access and good availability of mobility services increasingly replace private car use. In the United Kingdom, the decline in car travel was partly, and in Germany fully, compensated by an increased use of alternative modes of transport. (Kuhnheim et al., 2012.) In Stockholm, Sweden, only one in ten 18-year-olds gets a driving license (Aretun & Nordbacke, 2014). In the USA, nearly one in five young adults do not have a driver's license (Department of Transportation 2017; also Klein & Smart, 2017). This trend is also identified in Helsinki, Finland (Brandt & Lindeqvist, 2016). The most important factors
of mobility services are privacy, flexibility and autonomy. Costs and time efficiency also play a major role (Clauss & Döppe, 2013).

The research on Kyyti use gives similar signs of the emerging behavior change. However, as the respondents of this survey had only a maximum of 2-3 months experience from Kyyti use, we cannot draw strong conclusions based on this survey yet. The mobility behavior, not to mention car ownership, takes longer to change. The strongest evidence for possible changes in mobility and car ownership is that Kyyti really seems to offer a solution especially for car owners and users who are not so keen on using public transport or walking/cycling regularly. If Kyyti users would have been mainly from car-free households, the impact for car use reduction would not have been very probable. A follow-up research after one or two years is required to find out, whether Kyyti has had a permanent impact on mobility behavior or not.

The other strong result of the research is, that there is a significant difference between weekly and less frequent Kyyti users. As the biggest impact on the mobility behavior and operational efficiency comes from the weekly users, the needs of these users should be the ultimate guideline for the service design, regardless that the user base growth comes from the occasional weekend users still for a long time. Car ownership and use won’t change if we cannot provide ride services, that are easy and economical to use also on a weekly basis. Public transport and cycling are never enough to cater for all mobility needs on a large scale, especially for those who are used to having and using their own car. However, even a small share of weekly users can result in a big impact at the system level as the change in their use is more radical than for the occasional users.

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User Perspectives on Emerging Mobility Services: Ex Post Analysis of Kutsuplus Pilot

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ABSTRACT

Kutsuplus was a novel, flexible micro transit service (FMTS) operating in the urban parts of Helsinki during 2012 to 2015. The service included a range of new technological development, ranging from routing algorithm to marketing and user interface. However, at the end of 2015, the service ended due to budgetary constraints. In the context of service discontinuation, and the lack of in-depth understanding of user perspectives about urban FMTS, this paper aims to uncover the perspectives of the actual (non)-users of the system. The methodological approach bases on a questionnaire, with mapping capabilities enabling collection of georeferenced data. The results show that Kutsuplus users had a range of socio-economic and travel behavior features. In addition, the results include detailed analysis of stated trip characteristics. Furthermore, the results include qualitative analysis of respondents’ opinions and recommendations about positive and lacking FMTS features. The paper ends with a summary of positive Kutsuplus features, followed by the discussion of aspects for future deployment, including end-user and service area analysis, marketing strategy, and service usability. Finally, the paper provides recommendations for further research on FMTS.

KEYWORDS Flexible Micro Transport Service, Automated Demand Responsive Transport, Transportation Network Company, Urban Mobility, Paratransit
INTRODUCTION

Transport plays an essential role in tackling sustainability challenges in the cities of the 21st century [1]. A range of opportunities arise from the increasing number of available transport modes, range of pricing options, mobility-on-demand services, and changing user expectations. Flexible micro transport services (FMTS) are located in a continuum between taxi and bus service, and ranging from less formal community transport to area wide networks. These new services aim for near or door-to-door mobility, providing an alternative to passenger car use [2]. Consequently, FMTS provide an alternative between the high flexibility and high cost taxi service, and the low price, lower quality, and medium flexibility bus-based public transport. The additional dimension of FMTS flexibility is variability of service and fare level. An example of recent relevant development includes the emergence of transportation network companies, such as Uber, Lyft, and Split, that are centered on user-focused demand-responsiveness and sharing [3, 4].

Also known as demand-responsive transport (DRT), FMTS without fixed routing have commonly been associated with rural areas having a lack of public transport, or as service for people with disabilities [5, 6]. However, with the advent of information-communication [7] and real-time routing technology [8, 9], DRT services have the potential to become a viable transport option in the urban areas [10]. This research focuses on Kutsuplus, the large-scale FMTS pilot in the Helsinki Capital Region (HCR), Finland [11]. The service has been operational from October 2012 until the end of 2015, under the responsibility of the regional transport authority, Helsinki Region Transport (HSL). The HSL Executive Board decided that Kutsuplus in its current form would cease at the end of 2015, due to financial reasons [12]. Despite the cancelation, as a unique pilot in an urban area, Kutsuplus provides valuable lessons for planning and policy-making of future urban FMTS. In particular, the pilot is especially important for providing lessons on user perspectives and transferability, which is the focus of this paper. To this end, the next section presents a more detailed description of the Kutsuplus pilot. Section three presents the methodological approach based on a questionnaire. Section four includes results, while section five provides a discussion on lessons learned from the pilot, with conclusive points and suggestions for future research topics. This research builds upon the understanding of operational characteristics and technological advancement, as well as experiences from previous DRT case studies [6, 13-16].

BACKGROUND

In order to contextualize the development trajectory of Kutsuplus [17], this section presents the essential background information about the service. The Kutsuplus service was an advanced form of FMTS operated by HSL. However, Finland had previous experience with DRT, starting from 2003 recommendations for a national policy [14]. Kutsuplus service relied on a combination of technologies, including automated vehicle location, trip combination optimization, vehicle routing, and travel time estimates. The user would receive trip offer(s) by requesting a trip via browser-based interface or via SMS. Trip request involved specifying origin and destination, number of seats needed, reserve space for a pram if needed and earliest possible departure time. The earliest possible departure time was initially a maximum of 60 minutes; in later stages this was shortened to 45 minutes during normal operation and 30 minutes on busy campaign days. The offer to the user would then include pickup time, estimated time window for arrival, and predefined price. Trip offering and vehicle routing process was completely automated, without the need to involve the driver or the operator. The service used an advance payment with user account having preloaded monetary value. In
addition to the option of individual account wallet, companies had an option to establish their own company account wallet.

The service started with 10 microbuses, with additional five vehicles being added on November 18, 2013. These microbuses had a seating capacity of nine passengers, with side steps, wireless Internet access, and real-time passenger travel information about the expected time of arrival at the destination. Service was stop-to-stop, without requiring transfer between transport vehicles. At the start of the pilot, the operating time was 9:00 - 17:00, only during weekdays. This time was extended to 7:30 - 18:30, 6:00 - 23:00, and 6:00 - 24:00 in November 2012, November 2013, and November 2014, respectively. Figure 1 below shows the Kutsuplus service area, defined roughly as the inner side of the ring road one, encircling the Helsinki downtown area. The service area was roughly within 9 kilometers radius of the city center. In the year 2012, the mode split for residents of the City of Helsinki was 34% public transport, 29% passenger car, 29% walking, 6% bicycling, and 2% other [18]. In addition, there were about one thousand bus stops in the area. These stops were supplemented with around fifty virtual stops in places where the density of the regular bus stops was too low, or to account for special case situations, such as proximity to hobby area for kids or an important location for the elderly that reduces the walking distance on a slippery surface during winter. It is important to note that service was subsidized by the member municipalities of the HSL region.

![Figure 1: Kutsuplus coverage area (Background map © Open Street Map)](image)

HSL has made several small campaigns about Kutsuplus service, using both digital and social media, as well as outdoor and print ads. However, the annual marketing budget was ranging between €100,000 and €200,000, and was divided evenly during the year. Thus, each campaign was small in scope. In addition, HSL staff has faced a dilemma in choosing the marketing target group. The marketing campaign used an online platform
for asking users about potential Kutsuplus use scenarios. Moreover, social media advertising through posts and testimonials has been used extensively, accompanied with printed material about the ordering process. In general, the marketing emphasis was on service novelty, smart technology, and a futuristic way of traveling. For three campaigns, free trial-days were offered. In addition, celebrities were involved in trying out the service to attract publicity. However, price was not used as a part of the marketing efforts.

Table 1 below describes service classes used across pilot period, and comparison to taxi trip cost. In general, the trip pricing was based on the fixed starting fee, and the kilometer price calculated as the direct distance between origin and destination. The service has included a group discount of 20% for 2 passenger bookings, 30% for 3 passenger bookings, 40% for 4 passenger bookings and 50% for bookings with 5 passengers or more. In early 2015, time-of-day based discounts were introduced in the service, introducing lower “happy-hour” pricing for trips outside of the peak period. In comparison, internal ticket price for public transport is €3, two-zone ticket is €5, while for those having a season ticket one average trip approximately costs €0.66. Users could obtain an estimate of the price for their intended trip using a pricing simulator on the Kutsuplus web page.

Table 1: Service classes and their pricing in the Kutsuplus service

<table>
<thead>
<tr>
<th>Date of inclusion</th>
<th>Unnamed / “Kutsuplus”</th>
<th>“Normal”</th>
<th>“Economy”</th>
<th>“Fast”</th>
<th>Taxi</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.10.2012</td>
<td>1.88 € + 0.19 €/km</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5.70 € + 1.48 €/km</td>
</tr>
<tr>
<td>08.02.2013</td>
<td>-</td>
<td>1.88 € + 0.19 €/km</td>
<td>1.50 € + 0.15 €/km</td>
<td>-</td>
<td>5.70 € + 1.48 €/km</td>
</tr>
<tr>
<td>11.03.2013</td>
<td>-</td>
<td>1.88 € + 0.19 €/km</td>
<td>1.50 € + 0.15 €/km</td>
<td>2.63 € + 0.26 €/km</td>
<td>5.70 € + 1.48 €/km</td>
</tr>
<tr>
<td>03.04.2013</td>
<td>-</td>
<td>3.50 € + 0.45 €/km</td>
<td>2.80 € + 0.36 €/km</td>
<td>4.90 € + 0.63 €/km</td>
<td>5.70 € + 1.48 €/km</td>
</tr>
<tr>
<td>18.11.2013</td>
<td>-</td>
<td>3.50 € + 0.45 €/km</td>
<td>2.80 € + 0.36 €/km</td>
<td>-</td>
<td>5.36 € + 1.38 €/km</td>
</tr>
<tr>
<td>12.01.2015</td>
<td>3.50 € + 0.45 €/km, 20% discount from 10AM to 2PM</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5.90 € + 1.55 €/km</td>
</tr>
</tbody>
</table>

Operational Experiences

During the operation, the number of annual service trips grew steadily, reaching almost 100,000 trips in 2015 [19]. In addition, the vehicular efficiency showed an upward trend, efficiently combining trips, despite the limited fleet capacity. By 2015, vehicles had almost 55,000 annual vehicle hours, and around 1.8 trips per vehicle hour. Similarly, the trend has been positive in the number of registered Kutsuplus accounts, reaching total of 32,193 users. Moreover, users requested service expansion geographically and temporally on a daily basis. The reliability of the service was high, as 35% of pick-ups were within a +/-30-second range [19]. Customer satisfaction survey done by HSL showed an overall rating of 4.7 out of five, which is higher compared to typical score of 4.2 for traditional public transport in HSL region. In total from 2012 to 2015, the service had an operating revenue of €895,400, and service costs of €7,821,400. Including personnel expenses of €907,800, other expenses and depreciation, have resulted in net income being -€7,913,200. However, despite the fact that subsidies continued to grow through the operating period, the subsidy per trip
has been decreasing steadily, ending being just above €20 per trip in 2015. Moreover, the range of benefits that have been argued for include for example reduction in traffic accidents, environmental pollution, parking area construction and land use, road infrastructure maintenance, etc. [20].

METHODOLOGICAL APPROACH

In order to investigate user perspectives about Kutsuplus, this research has focused on understanding socio-economic and travel behavior background of users. In addition, the research focus was on underlying reasons for using or not using the service, as well as on gathering user comments and recommendations. For the research approach, the research team has decided to use web-based questionnaire with mapping capabilities, commonly used in participatory planning practice [21]. The survey was available in three languages: English, Finnish and Swedish. In order to make the user interface easy and attractive for the respondent, the survey was divided into sections. The questionnaire structure is shown on Figure 2. The first part of the survey asked about respondent’s background. In addition, this part involved the main filtering question about the use of Kutsuplus service. Based on the answer to the filtering question the survey divides the participant in three user groups, i.e., those that have used Kutsuplus and would have continued using it (group 1), those that have used Kutsuplus and have decided to stop (group 2), and finally those that have never used Kutsuplus (group 3). Based on this filtering question, the respondent was asked different questions about Kutsuplus service.
In the second section of the questionnaire, participants from group 1 and 2 were asked to provide georeferenced information about their trip origins and destinations while using Kutsuplus (Figure 3). The third questionnaire section asked for information about the trips and user experiences with Kutsuplus service, including reasons for using and discontinuing the service. Due to the ex-post nature of the study, the subjects were asked to provide answers about any trip they want to highlight, while providing them with examples, such as most-common trip. This section was also the only section those that have not used the service would see, as they would be asked about their reasons for not using the service, and for recommendations on improving Kutsuplus service in the future. The survey was active from April 15 to May 6, 2016. The survey was advertised in three different campaigning rounds with a week break after the initial posting date. The link to the survey was advertised repeatedly on social media such as Facebook, Twitter, and sent by email to registered Kutsuplus users.
Collected data was checked for incomplete responses, and partially translated. Through visual analysis, georeferenced trips have been checked for validity, removing trips that do not fall within the service area. This process has included the removal of some very short trips or trips outside of the Kutsuplus service area, as these might have resulted from the respondents’ unfamiliarity with the mapping feature in the questionnaire. Based on the data collected, the analysis includes the following groups:

- Quantitative analysis of user responses;
- Geospatial analysis of user-provided trips;
- Qualitative analysis of users’ comments;

The following section will present results of the analysis in detail.

**RESULTS**

The total number of survey respondents was 1440. The response rate varies depending on survey question due to the nature of the mandatory and optional question asked. This is followed by a section describing the use of Kutsuplus through various trip characteristics.

**Summary Results**

Table 2 shows the cumulative number of responses for the background information questions. Table 3 below shows the summary of the responses for questions regarding Kutsuplus service. The respondents of the survey represent a broad spectrum of people from every age and income class. Most of the questionnaire respondents were former Kutsuplus users (72%). The majority of respondents has used Kutsuplus 2 to 5 times. Moreover, the highest percentage of trips had social or recreational purpose, similar to general trends in HSL region. Trips were spread out across the day, with peak in the afternoon. Respondents were usually traveling alone, while there were one to three other passengers sharing the vehicle simultaneously. Finally, Table 3 also shows reasons for choosing Kutsuplus, for stopping using it, and for not using it at all.
### Table 2: Respondents’ background information

<table>
<thead>
<tr>
<th>Question</th>
<th>Stated Answers</th>
<th>No. of Responses</th>
<th>Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>618</td>
<td>1417</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>791</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td><strong>Age groups</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18-30 years</td>
<td>283</td>
<td>1425</td>
</tr>
<tr>
<td></td>
<td>31-45 years</td>
<td>561</td>
<td></td>
</tr>
<tr>
<td></td>
<td>46-65 years</td>
<td>464</td>
<td></td>
</tr>
<tr>
<td></td>
<td>66 and Above</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td><strong>Household Income</strong></td>
<td></td>
<td></td>
<td>1400</td>
</tr>
<tr>
<td></td>
<td>Less than 2000</td>
<td>184</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2001-4000</td>
<td>382</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4001-6000</td>
<td>302</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6001-8000</td>
<td>212</td>
<td></td>
</tr>
<tr>
<td></td>
<td>More than 8000</td>
<td>207</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td><strong>Car usage frequency</strong></td>
<td></td>
<td></td>
<td>1358</td>
</tr>
<tr>
<td></td>
<td>Never</td>
<td>319</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Daily</td>
<td>302</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-4 times a Week</td>
<td>318</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Once a Week</td>
<td>182</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Once a Month</td>
<td>237</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>111</td>
<td></td>
</tr>
<tr>
<td><strong>Taxi usage frequency</strong></td>
<td></td>
<td></td>
<td>1053</td>
</tr>
<tr>
<td></td>
<td>Never</td>
<td>240</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Daily</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-4 times a Week</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Once a Week</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Once a Month</td>
<td>634</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>393</td>
<td></td>
</tr>
<tr>
<td><strong>Kutsuplus usage</strong></td>
<td>Used and Continued</td>
<td>939</td>
<td>1419</td>
</tr>
<tr>
<td></td>
<td>Used and Discontinued</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Never Used</td>
<td>390</td>
<td></td>
</tr>
</tbody>
</table>
Table 3: Summary of responses related to Kutsuplus service

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer Choices</th>
<th>No. of Responses</th>
<th>Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trips by Kutsuplus</td>
<td>1 time</td>
<td>77</td>
<td>908</td>
</tr>
<tr>
<td></td>
<td>2-5 times</td>
<td>271</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6-10 times</td>
<td>195</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11-20 times</td>
<td>167</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21-30 times</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Over 30 times</td>
<td>126</td>
<td></td>
</tr>
<tr>
<td>Purpose of trips</td>
<td>Going to work/school</td>
<td>269</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Business-related trip</td>
<td>263</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shopping trip</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social/recreational trip</td>
<td>575</td>
<td></td>
</tr>
<tr>
<td>Trip time during the day</td>
<td>Morning (6 to 10)</td>
<td>248</td>
<td>1486</td>
</tr>
<tr>
<td></td>
<td>Mid-day (10 to 15)</td>
<td>299</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Afternoon (15 to 18)</td>
<td>414</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evening (18 to 21)</td>
<td>359</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Late Night (21 to 24)</td>
<td>166</td>
<td></td>
</tr>
<tr>
<td>Accompanying passengers</td>
<td>Alone</td>
<td>662</td>
<td>856</td>
</tr>
<tr>
<td></td>
<td>2-3 Group</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-9 Group</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>Other passengers in the vehicle</td>
<td>0</td>
<td>174</td>
<td>841</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>306</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-3</td>
<td>298</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3+</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Reasons of making trip by Kutsuplus</td>
<td>Lack of good public transport connection</td>
<td>379</td>
<td>1727</td>
</tr>
<tr>
<td></td>
<td>Low cost of Kutsuplus compared to taxi</td>
<td>529</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fast travel choice compared to public transport</td>
<td>516</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of parking spaces and other problems with using personal car</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Easiness of ordering a trip</td>
<td>204</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>132</td>
<td></td>
</tr>
<tr>
<td>Reasons for discontinuing Kutsuplus</td>
<td>Booking and paying fare was complex</td>
<td>16</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Long walking distance to stop/pickup point</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trip cost of Kutsuplus was high</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Use other public transport (bus, tram, metro)</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>Reasons for not using Kutsuplus</td>
<td>I did not know about this service at all</td>
<td>62</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>I had some information about the service but not enough to order the service</td>
<td>107</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The service had no pickup point near my home or work place</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The service area did not include other places of my interest</td>
<td>38</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>Fare was too high</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>87</td>
<td></td>
</tr>
</tbody>
</table>
Respondents' Characteristics

Figure 4 shows Kutsuplus use in relation to respondents' age and income. The age and wealth distributions within the sample differs between the groups defined by Kutsuplus usage. Overall Kutsuplus was used by all age groups and all income sizes. However, the respondents who did not try Kutsuplus tend to be younger and have lower income. A probable explanation is the demographics of the various data collection channels. It is safe to assume that the respondents reached by e-mail include mostly Kutsuplus registered users, while the persons reached via Twitter and Facebook contain a mix of Kutsuplus users and non-users. In addition, the sample did not indicate large differences among Kutsuplus users with respect to gender.

Figure 4: Kutsuplus use in relation to a) Age and b) Income

Figure 5 depicts respondents' Kutsuplus use in relation to car use and taxi usage frequency. In general, Kutsuplus has achieved a solid user base from those that regularly use car (daily and up to four times a week). However, contrary to the expectations, the majority of respondents that have used and planned to continue using Kutsuplus still belonged to less frequent car users. On the contrary, majority of respondents that have used Kutsuplus rarely use taxi service. One category of respondents that have never used Kutsuplus have also never used car or taxi, which places them in a category mainly dependent on conventional public transport.
Figure 5: Kutsuplus use in relation to a) Car use frequency and b) Taxi usage frequency

General and Spatial Characteristics of Kutsuplus trips

The diverse user base of Kutsuplus is reflected by the stated trip purposes (Figure 6). The questionnaire contained four predefined classes: going to work/school, business related trip, shopping trip and social/recreational trip. Based on the open answers two other classes of trips were identified: healthcare-related trips and children-related trips. Social/recreational trips were the largest class in all age groups. This trip purpose was also the most common throughout the day, except for the morning (6 to 10), where trips to work and schools were more common. When comparing the trip purposes to the results of the HSL travel survey, the most striking difference is the large proportion of business-related trips with Kutsuplus [18]. Comparing to around 20% of business-related Kutsuplus trips, only 3% of all trips were business-related in the Helsinki region travel survey. In addition, the variation between age groups was relatively small. Hardly surprising, the only exception is the oldest age group (66 years or older), where the number of job and business related trips are few while the recreational, healthcare-related and children-related trips have a higher proportion.
The group of miscellaneous trips, with open ended answers that could not be assigned to any of the existing or new trip classes, included such trips as traveling with heavy luggage or pets, as well as trips to the ferry harbors in the inner city, without clarification of the trip purpose.

The following Figure 7 to Figure 9 show common trip origins and destinations, desire line distribution, and trip length distribution. In Figure 8, numbers in rectangles represent trips between zones (administrational district areas), while number in circles represent the number of internal trips. Based on the trip data collected in the survey, the highest concentration of origins and destinations were in the inner city, especially the central business district. These are the densest parts of the city both regarding population and job density,
as well as public transport network. Other hotspots are found in the Otaniemi campus and business area, Arabianranta (campus, business and residential), Munkkivuori (residential and business) and Lauttasaari (residential and business). In general, the peripheral areas had fewer origins and destinations, Otaniemi being the main exception. This would be partially expected due to the lower population and job density. A majority of the trips were done between and within the three central areas and the Otaniemi area. Trips orbital or transversal to the city center were fairly uncommon. The trip length distribution shows a drop in the number of trips longer than nine kilometers, with largest group being trips between four and five kilometers. This distribution reflects the size of the service area and the fact that most trips are directed towards or within the central areas.

![Figure 7: Common trip a) origins and b) destinations](image-url)
Figure 8: Desire lines for trips using Kutsuplus

Figure 9: Trip length distribution
Trip Data Analysis

**Figure 10:** The monthly number of trips, accepted offers and the vehicle productivity in the Kutsuplus service between October 2012 and December 2015.

Respondents' Opinions and Recommendations

The following Figure 11 shows the respondents rating of Kutsuplus service on a scale of one to five, with five being the maximum, and based on the decision to continue using Kutsuplus. One can conclude that the rating is more frequently higher for respondents who have not decided to stop using Kutsuplus, compared to those who have decided to stop using it. A weighted average score for those that have not decided to stop using the service is 4.64, while it is 3.74 for those that have decided to stop using the service.

**Figure 11:** User rating in relation to service continuation
Figure 12 shows respondents’ comments regarding the reasons for using Kutsuplus, for deciding to stop using Kutsuplus, and reasons for not using Kutsuplus, classified according to respondents’ income category. One can conclude that most common reasons for using Kutsuplus are lack of good public transport connection, low cost compared to taxi, and fast travel choice compared to taxi. In addition, issues with using a car have been more often highlighted by respondents from higher income categories. Miscellaneous reasons for using Kutsuplus included curiosity to try new service, fast travel when accompanying a child, and traveling with heavy or large goods. Lower income categories mostly selected trip cost and use of other public transport modes as a reason for stopping the use of Kutsuplus. On the contrary, vehicle unavailability and long response times has affected more than 35% of respondents from higher income groups to stop using the service. Miscellaneous reasons for stopping the use of Kutsuplus included no advance ordering feature, longer travel time from estimated, slower service compared to other public transport, removal of “fast” travel option, or failure to pick up after ordering. Respondents that have not used Kutsuplus service most frequently highlighted the lack of knowledge about the service. For the respondents in the lowest income categories, the service area was not often perceived as a problem, as opposed to fare level, where all the complaints originate from this income group. One can observe a significant percentage of answers classified as miscellaneous. These responses included difficulty in ordering, limited service time, assumptions about comfort and reliability in comparison to taxi and car use.
The questionnaire contained two open-ended questions asking specifically about the positive Kutsuplus features and about suggestions for improvement in the case the service is relaunched. The first question was only directed to persons who had used the service while the second question was available for all respondents. As the questions were not structured, the answers varied in scope and quality. However, the answers were categorized based on the content.

The results in the open-ended question regarding the main positive features of Kutsuplus followed the pattern of the answers to the structured question regarding why Kutsuplus was used. Both in the structured and
the open ended questions the respondents greatly appreciated speed, affordability and to some extent the ease of ordering Kutsuplus. Kutsuplus was seen as complementing lacking public transport, both spatially, neighborhoods with bad connections but also temporarily at times of day when public transport is infrequent. The respondents also mentioned the comfort and appliances of the Kutsuplus vehicles (e.g., wireless Internet, electric socket), flexibility, reliability and the general effortlessness as positive features. In addition, the drivers were seen as friendly and helpful. Many appreciated the travel information, mainly in the form of an online real time map where the Kutsuplus vehicles could be monitored. Less common answers mentioned the ease of traveling with heavy baggage, as sick or as disabled. Safety and children were often mentioned in the same answers, as some saw Kutsuplus as a safe way to send children alone to their hobbies or school. The fact that parents could order the trip, pay and even track the vehicle, enabling a checkup call were seen by some as key safety features. Kutsuplus was also seen by some as a safe way to get home in the evening. Some answers were very specific, such as appreciating the air-conditioned vehicles or removing a hassle of owning a car, while others answered from a general view, e.g. by stating that the service improved the quality of life or is innovative and modern.

Despite the many positive features of Kutsuplus and the high rating, both users and non-users found room for improvement of the service. One often commented feature was the limited size of the service area, with various suggestions for expansions. Commonly suggested expansions were to cover the whole urban area of Helsinki or add specific areas close to the current service area. The most common suggestion was adding the Helsinki airport, located at the extreme northern point of the urban area. In some answers the service area was seen as wrongly allocated to the areas with already functioning public transport and that the emphasis should be on complementing or even replacing lacking public transport services with Kutsuplus. One suggestion considered removing Kutsuplus altogether as an option for trips with traditional public transport that do not require transfers. The non-users often lived outside the service area which rendered the service useless for them. Many also wanted to improve the service coverage within the current service area by adding new stops. Especially healthcare facilities were suggested as locations for new stops as the persons needing medical treatment often are the ones benefiting most from short walking distances. There were many suggestions regarding an expansion in the temporal dimension. Both late evening, night and weekend service were frequently suggested.

Several respondents criticized the fare collection system. Prepayment was seen as inconvenient as it added an extra, often seen as unnecessary, step to using the service. Many respondents perceived the lack of payment alternatives as an obstacle for new users, as this required an effort to learn how to use the new system. Several alternatives were suggested, such as credit card payment, travel card payment, payment trough phone bill or even cash. Another suggested payment option was based on a monthly subscription. Moreover, many respondents had opinions regarding pricing. Some demanded lower fares for everyone, but discounts were also suggested for special cases such as students, persons with a public transport season ticket, families and groups. Of these the group discount was already implemented, but perhaps poorly advertised. Some users also pointed out that pricing information was hard to access, especially for people that did not yet have an account but wanted to try the service. Despite many respondents hoping for a more affordable service there were also few respondents willing to increase the fares, especially for a potential weekend service or a for a re-implemented “fast” service without combined trips.

Many respondents have perceived ordering as functional. However, especially elderly persons would have hoped for an easier to use trip ordering interface or alternative ordering systems such as SMS ordering.
(that was implemented in the later stages), or ordering through phone service. In addition, there were few suggestions of integrating the ordering of Kutsuplus into the HSL online route planner used for traditional public transport. This would have made possible the direct comparison between traditional public transport and Kutsuplus. Many respondents have highlighted the small time window for ordering trips of typically 45 minutes before the desired departure as problematic. The possibility of advance ordering was frequently suggested, with the time range varying between a few hours to several days. Kutsuplus also lacked the possibility to order a trip with a requested latest arrival time. A less common request was to improve taking into account persons with daily need for trips with the same origin, destination and time of travel. Another suggested feature would have been the possibility to order a pick-up or drop-off chain for a group with a common destination or origin respectively. Many respondents would have preferred an application for smartphones instead of an Internet browser based user interface. The Uber app was often mentioned as a good reference for an app design.

According to some respondents the reliability of the Kutsuplus system was deteriorating during rush hours as the passenger numbers grew. The decreased reliability took the form of long response times for the Kutsuplus vehicles, and longer or at least decreased travel time reliability. One reason mentioned by respondents for the decrease in travel time reliability was that it became more common that the trip would be combined with someone else’s. The increased unreliability regarding response and travel times in combination with the ordering system that only allowed ordering 45 minutes before the desired departure time made Kutsuplus a “risky” option for trips where being on time was necessary. In a worst case scenario, Kutsuplus would not be available and in addition it would be too late to use any alternative modes. A few respondents stated that these factors forced them to at least partially abandon using the system. The long response times also hindered some of the respondents to try the system. As a solution many suggested an increase in the number of Kutsuplus vehicles or alternatively integration with the taxi system.

Based on the low number of suggestions regarding the Kutsuplus algorithm, it can be assumed that the system worked well from this perspective. However, there were a few mentions of situations where the passenger was close to the destination, but yet the Kutsuplus vehicle turns back to pick up passengers far away in another direction. Another user suggested that there should be a cap on how many trip combinations would be allowed, to secure an acceptable travel times. To speed up passenger pick up, the algorithm was suggested to be changed so that the pick-up stop would be on that side of the road that required the minimum amount of U-turns for the Kutsuplus vehicle.

The lack of marketing was by many seen as one of the main failures. Especially the respondents who had not tried the service would in many cases have liked to be informed about this option. Respondents wanted more information and detailed explanations of how to use the service. A free first ride was by some respondents seen as a good marketing trick. Many of the Kutsuplus users tried to recommend the service to friends and relatives. A common misconception encountered by them was that Kutsuplus was meant for elderly, as the service routes use similar microbuses. On the other hand, some respondents wanted vehicles with improved accessibility to indeed make it easier for elderly and disabled to use Kutsuplus.
DISCUSSION AND CONCLUSIONS

Kutsuplus service, as a unique pilot of urban FMTS in the world, enables a range of lessons. The service has involved a significant technological development, combining various data sources in real time. In addition to the advances in FMTS technology, the pilot has enabled a range of empirical lessons related to marketing, fare policy, user interface, and spatial aspects. During its operation from October 2012 to the end of 2015, Kutsuplus had a growing user base, which also included frequent private car users. In addition, Kutsuplus had a growing number of annual trips, improving vehicular efficiency, high reliability, and decreasing subsidy per trip. In addition, user satisfaction had consistently high overall rating, of around 4.7 out of five. The high user satisfaction has also been observed from the respondents in this research.

Discussion on results

In detail, Kutsuplus has been used for a range of trip purposes. However, socio-recreational trip purpose has been the most frequent one, with addition subcategories emerging, such as healthcare or child-related, or travel with luggage or pets. Moreover, Kutsuplus trips were geographically spread out over the whole area. However, most frequent trip origins and destinations centered on several, mostly business-related, locations. In addition, most Kutsuplus trips were below nine kilometers, which coincided with the radius of Kutsuplus service area. In summary, Kutsuplus had a range of positive features that have attracted and kept the users, including:

- Good complementation with public transport in areas of low public transport accessibility;
- Low cost for the end user;
- Fast travel compared to public transport;
- Reduction in car-related issues, such as finding parking;
- Easiness to habituate into travel behavior once familiar with service;
- Benefit for special groups users (e.g., traveling with luggage, sending children);
- Riding comfort and amenities in the vehicle, including real-time information;
- Safety during traveling;
- Friendly staff;
- Innovativeness of the service.

Being operated as a publicly funded pilot, facing a gradual withdrawal of the fare subsidy, Kutsuplus had limitations with the operating budget. Despite the fact that the financing of the service, with an issue of available fleet size in particular, has become a significant obstacle for service continuation, several other groups of features that could have been improved are identified in the Kutsuplus’ development trajectory. Contrary to the public discourse, the research result implicate that financial obstacles were just a “tip of the iceberg”. In fact, there were several factors, where each of the factors is not significant in itself, but in combination with other factors introduces barriers for successful technological transition. These inadequacies are also important focal points for future deployment of DRT services in urban environments.

- First group of lessons relates to end user analysis. As a potential area of improvement, future urban DRT services should dedicate significant effort in clearly identifying the end user target groups. Moreover, service planning should avoid spanning over a range of users, from an alternative to car-dependent travelers to a service for all. In addition to end user analysis, the analysis should also focus on spatial and
temporal patterns, with the potential to advance stop location as well as vehicle scheduling and routing mechanism.

• Similarly, marketing strategy should reflect the end user target group, and avoid solely focusing on advertising but also aim at education on how to use the service. To this end, the marketing campaign could deploy “soundbite” length visual media, aiming at frontloading the education effort at the start of the service. In addition, an analysis of marketing media is required, if one aims at particular groups of potential users (e.g., are car-dependent users reached in social media?).

• A third group of recommendations relates to service usability, where service should use both online and SMS booking system, as well as enabling preordering more than 45 minutes in advance. The capabilities of online environments also allow for integration of the booking system with existing public transport routing planners. In addition, improving usability relates to integration into the existing public transport fare system, as well as enabling post-paid options, such as credit card or phone bill charge.

Discussion on limitations and future research

The implemented methodology involved several tradeoffs, despite the relatively large survey sample. First, as the survey was conducted after the service termination, users’ perception might have been skewed due to the closure, increasing the likelihood of higher emotional responses supporting the service resumption. Second, the dissemination channels used might have resulted in some bias of the sample composition, attracting the users who were in favor of the service, as opposed to random sampling. As the number of respondents reached through various media channels is unknown it is impossible to define a distinct response rate, and consequently provide additional comments on the dissemination channel effect. Third, the survey design involved a compromise between the length and a range of questions asked. For example, some additional questions, such as usage and perception of public transport could have been included. Instead, a proxy question of car and taxi service usage was used. Fourth, considering the range of changes during the pilot, additional questions related on the period of using the Kutsuplus service could have provided more insight into the contextual user experience.

However, as this research highlights the complexity of breaking the car dependency in the urban transport systems, pointing out a range of interdependencies that play a decisive role in success of FMTS, there are several other opportunities for further research. First aspect is focusing on in-depth analysis of users and non-users travel habits, and the role that Kutsuplus service had in shaping them. Second, there is a need for detailed analysis of actual trips served by Kutsuplus, as well as comparison with other modes, such as passenger car and public transport. Finally, there is a need for developing policy and planning recommendation for integrated planning and operations of FMTS and static public transport network service.

Acknowledgment

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MaaS and sustainability
A Comparative Analysis of Vanpool and Single Occupant Commuters’ Self-reported Stress Level Before and After the Commute

CRISSY DITMORE & DEVON DEMING

ABSTRACT

The purpose of this study was to examine commuter behavior to determine if those that use a vanpool (VP) to commute to and from work experience a different level of stress than their single-occupant vehicle (SOV) counterparts. In this study, survey respondents provided their personally perceived level of stress both before and after their commute on a scale between one and ten. Qualitative analysis of the change reported as a number, was followed by statistical analysis by applying confidence intervals to infer the probable range of median values for each data set. The average within each dataset was used to determine the change. Overall, the aggregated data revealed that the vanpool set experienced a 21% lower rate of self-reported stress than their single occupant vehicle counterparts specific to the commute. The results provide insight into the effects of stress when choosing a vanpool as a primary commute mode by using SOV commuters as a control group. Additional data from one of the participating employer sites provided enhanced understanding of other metrics that could contribute to overall wellness or personal satisfaction. Analysis of the data revealed additional behavioral insights between the commuter modes including reduced absenteeism for the vanpool participants. This information can help people understand motivating factors that may alter commute mode choice based on a desire to lower stress. It may also assist employers in understanding the kind of value these types of services bring to their employee base. Both provide implications for enhancing MaaS options and perhaps increasing its adoption to a wider audience.

KEYWORDS Vanpool, Carpool, Single-Occuapt Vehicle, Mobility as a Service (MaaS), Commute
Purpose

Mobility as a Service (MaaS) is steadily gaining popularity as a concept in the provision of transportation service. However, forms of MaaS have been around for decades. For instance, vanpools began in the 1970’s and are groups of commuters who live and work in generally the same area and choose to commute as a group in a passenger vehicle. In many cases this can be an informal grouping of colleagues traveling in a personal vehicle. In the U.S. the majority use this service in a purchased transportation model from a private provider. Participants pay a fee and the private provider offers varying levels of service, and at a minimum, provides the vehicle for a monthly fee to the group. The purpose of this study was to examine behavioral observations of two specific commute modes to determine if those that use a vanpool (VP) to commute to and from work experience a different level of stress than their single-occupant vehicle (SOV) counterparts. This was intended to bring the concept of psychographics, how people think and feel, to commuter -focused research. In this study, survey respondents provided their personally perceived level of stress both before and after their commute on a scale between one and ten. Qualitative analysis of the change reported as a number, was followed by statistical analysis by applying confidence intervals to infer the probable range of median values for each data set, which was used to measure the change. A separate study was conducted with one of the original participating worksites to determine the nexus between vanpool participation and workplace attendance.

Methodology

The processes used to design the survey and implementation tools took into consideration the confidentiality and expectation of privacy for respondents as evidenced in the Informed Consent procedure. For the survey, respondents were instructed on the Merriam-Webster definition of stress as “a physical, chemical, or emotional factor that causes bodily or mental tension and may be a factor in disease causation” (1) to use as a baseline to gauge their self-assessment. Then, each participant was asked “based on that, what is your level of stress for today’s commute?” All statistic methodologies used measure the change in stress as reported from before the commute and after.

Aggregated Data

There were three sites where the survey was performed, and each produced individual data outcomes. To determine the overall results for this study, the aggregate data files were compiled by including all data, without regard to site, into a single file and then analyzed. The data was separated only by commute mode and time of day. These aggregated files included only information for the VP (Vanpool) and SOV (Single Occupant Vehicle), all separated into morning and evening and before- and after-commute. For the purposes of this study the equation to determine the difference in stress between modes is:

\[
\begin{align*}
\lvert \text{VPB} - \text{VPA} \rvert &= \Delta \text{Stress} \\
\lvert \text{SOVB} - \text{SOVA} \rvert &= \Delta \text{Stress}
\end{align*}
\]

VPB is vanpool [before] and VPA is vanpool [after], while SOVB is single occupant vehicle [before] and SOVA is Single Occupant Vehicle [after]. The subtraction for the delta calculations is always before-commute self-assessed stress minus after-commute self-assessed stress.
To understand the results, a negative delta means that stress increased. A positive delta means stress decreased. Hence, an increase in stress produces a negative value.

The equation for determining the overall difference in stress level is:

$$\Delta = \frac{<\text{Stress} - >\text{Stress}}{<\text{Stress} = \Delta \text{ (expressed as a percent)}}$$

Such that:

If the $>\text{Stress}$ is also $[B]$ then the $\Delta$ is lower stress

If the $>\text{Stress}$ is also $[A]$ then the $\Delta$ is higher stress

To support the summary findings the data is:

<table>
<thead>
<tr>
<th>VPB</th>
<th>VPA</th>
<th>SOVB</th>
<th>SOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.64</td>
<td>3.47</td>
<td>3.25</td>
<td>3.88</td>
</tr>
</tbody>
</table>

| VPB – VPA | / VPB = .046 (5%) lower stress |
| SOVA – SOVB | / SOVA = .16 (16%) higher stress |

The VP is a 5% decrease
The SOV is a 16% increase

**RESEARCH METHODOLOGY**

The survey was designed to deliver initial vanpool data that can be the foundation for future research. The questions that were sent to participants in order of appearance in the survey are:

1. I commuted today: (Yes / No)
2. For the commute today I was a: (vanpooler, single occupant driver, other)
3. For the work-to-home (or home-to-work, depending on time of day) my level of stress is: (choose 1-10)
4. Gender: (Male or Female)
5. Age: (One of six choices based on generation)
6. My one-way trip in miles is: (one of five options based on distance)
7. For this trip I was a: (Driver, Rider)
8. Do you have any suggestions on the survey experience or thoughts you would like to share from your participation that would be helpful for the researcher to know?

For question one, if respondents did not commute that day, they defaulted to the end of the survey. There is no follow-up question for why they did not commute that day, because it is not pertinent to the data desired for this study. For future research it is important to note there could be many reasons for not commuting, which could range from sick, off work, or even working from home; which is commonly referred to as teleworking.

Respondents who answered anything other than vanpool or SOV for question two were also taken to the end of the survey to ensure responses were limited to only those two modes. Between questions two and three, additional information was given to the respondents to define a common methodology for judging their self-perceived stress level (the definition of stress from the dictionary as referenced above). Questions three and four both relied on the simple understanding of the definition of stress as it applies to this research. Additionally, lay language was added to increase understanding. The phrase “in other words, stress is a
factor in your daily experience that causes you tension or anxiety and could make you sick” followed the
dictionary’s definition of the word. Then, each participant was asked “based on that, what is your level of
stress for today’s commute?”

The respondents could then move to question three which had two parts: an indication of their level of stress
before they left home, and an indication of their level of stress after they arrived at work, or vice-versa,
depending on whether the survey was administered to morning or evening commuters. Questions four and
five were general demographic information—age and gender. Question six asked for the one-way mileage
and seven questioned whether they were a driver or rider. Question eight allowed for free form responses and
feedback on the survey itself, and yielded interesting information that may be helpful in future surveys but is
not included in this study. The scope of this research was limited to the before-and-after self-reported stress
levels of vanpool and SOV commuters. Before analysis, the survey information was wiped of all personally
identifiable information (PII), including IP address, e-mail information, etc.

SURVEY METHODOLOGY

It is recognized that there can be many factors that affect stress during the commute time. These factors
could include traffic, knowledge of impending events later in the day, workload, concerns at home, etc. The
purpose of this survey structure was to determine, even with all of those factors, does the commute mode
choice impact stress level. All statistic methodologies used are to measure the change in stress from before
the commute and after. Under this methodology the reasons for being stressed are not of concern. Most of the
stresses experienced by an individual would be experienced regardless of commute choice; for instance: both
SOV drivers and vanpool commuters experience traffic, although to different levels and in different ways.

All participants were given the same definition of stress each day to provide an equal frame of reference for
how to define stress over their day. Each survey was administered for a full 14 days. Given the self-reporting
nature of the data, it could be argued that there are individuals that would rate stress significantly different
in either direction than others. To minimize the impact of individual bias several sites were used, creating a
large sample size. The longitudinal nature of the study was designed to minimize any potential for bias in
the data due to these potential individual differences.

Using a Scale of One to Ten

There are many ways to measure stress. Hospitals use a numeric rating scale during triage of incoming
patients as a methodology for assessing patient symptoms. The ten-point scale is used in multiple settings
in addition to hospitals, including by the American Psychological Association (APA) in their annual report,
“Stress in America”™. For this annual study, the scale allows respondents to report their individually
perceived levels of stress in different aspects of their lives on a scale of one (little or no stress) to 10 (a great
deal of stress). Findings within the “Stress in America” report support the rationale of utilizing individually
perceived levels of stress to be used as an appropriate measurement tool, as reinforced over the long term of
the reports as reported annually, and across the nation from 2007-2014. Further, the APA stress report found
that when comparing East, Midwest, West and South regions, Americans report similar levels and sources of
stress. Regardless of where they live, Americans’ experiences with stress appear to be similar (2) (Figure 1).
FIGURE 1: Average stress level by region of the U.S. from the American Psychology Association “Stress in America” study 2015

This would indicate that the realized levels of commute-specific stress could mimic potential findings in other areas of the U.S. Confirmation of comparable levels would be further justified in future research, to see whether results are replicated across other areas of the U.S.

There is a broad space that different individuals can use to determine their individually conceptualized levels of stress. It is common knowledge that there are individuals with inherently higher or lower levels of tolerance. The longitudinal nature of this study maximizes the likelihood for statistically-valid data while minimizing the potential for bias in the individual self-reporting.

Findings

There were 5,515 individual responses received, including 70% SOV and 16% VP commuters. Over the term of the study, vanpool commuters reported a 21% difference in stress than the SOV commuters. Breaking down that number, vanpoolers reported a 5% decrease in stress, while the SOV commuters reported a 16% increase in stress.

On average, vanpool commuters had a slightly higher level of stress than their SOV counterparts before the commute. However, by the end of the commute the same group reported a lower level of stress than its original score, and a significantly lower reported level of stress than the SOV commuters. The evening commute vanpool participants showed a higher stress level before the commute compared to the SOV participants, which actually lowered after the commute. Conversely, the SOV commuters stated a lower level of stress than the vanpool commuters before their commute, and experienced a higher level of stress at the end of their commute.

Implications

The only category of commuter that resulted in less stress after their commute was the evening vanpool group. This could be an important behavioral marker to note; the vanpool group was able to start their evening at home with lower stress, which could be beneficial to the individual; further research is required to understand why. All other categories showed an increase in stress after the commute.
The many questions raised as a result of this study, such as “will other modes of transportation reflect similar reductions?” etc. reaffirm a need for ongoing research in commuter decision processes. This study provides a unique perspective into potential (even unrealized) motivating factors for vanpoolers as well as single occupant drivers.

BACKGROUND

Vanpools are commonly defined as a group of volunteer commuters who live and work in the same general area and agree to participate in a ridesharing arrangement. In the U.S. most vanpools qualify as public transportation. Public transportation is defined by Congress as regular, continuing, shared-ride, surface transportation service that is open to the general public or open to a segment of the general public defined by age, disability, or low income (3). Vanpools, by federal definition, must have seating for a minimum of seven and a maximum of fifteen passengers including the driver. The driver cannot receive any compensation for driving, but the participants can reduce their individual commuting costs by sharing expenses.

Vanpooling is one of the fastest growing modes of commuter transportation in the U.S. Unlike other modes of transportation, vanpools saw a retention of ridership even after fuel prices fell following the sharp spike in prices in 2007 as indicated by data in the National Transit Database (Figure 2).

![Change in Unlinked Trips 1998-2008](source: Federal Transit Administration, National Transit Database)

**FIGURE 2:** Increase in vanpool trips compared to other modes of transit. Source data taken from FTA, National Transit Database (2013)

This level of retention might be attributable to a realization of commuters’ cost savings over time, or to a better quality of life due to the commute shift, among possible reasons. The retention rate of vanpoolers over time is another reason why studying motivating factors behind commute choice could reveal important information regarding increasing vanpool use. It may also provide useful behavioral markers for other modes of service entering into the Mobility as a Service marketplace.
WHY IS THIS IMPORTANT?

Transportation currently accounts for 71% of total U.S. petroleum use, and 33% of the nation’s total carbon emissions (4). Identifying ways to remove potential barriers that prevent individuals from altering their commute behavior could increase participation. Increasing use of public transportation options could have the potential to lower the need for petroleum and reduce U.S. greenhouse gas emissions. This study attempts to gain a better understanding of one aspect—stress—as a possible motivating factor in mode shift, which is the decision by an individual to utilize an alternative form of transportation instead of using a single-occupant personal vehicle for travel. Understanding behavioral factors may enhance adoption of MaaS products overall, especially if used as a motivator for users.

This study attempts to measure stress as a result of the commute, with the commute itself being the only difference independent of mode choice. Not all stress is bad. Stress can be beneficial for some people, under the right circumstances. But, long-term, ongoing high stress levels have been known to cause medical issues. The World Health Organization (WHO) Global Burden of Disease Survey estimates that by the year 2020, depression and anxiety disorders, including stress-related mental and health conditions, will be highly prevalent and will be second only to ischemic heart disease in the scope of disabilities experienced by sufferers (5).

Insurance companies should have a stake in understanding whether a person’s commute choice affects their overall health, given the link between stress and health. Casualty and Insurance Edition of Best’s Review estimates that $150 billion of revenue is lost to stress annually in lost productivity, absenteeism, poor decision-making, stress related mental illness, and substance abuse (6). Understanding how stress is impacted by the commute is an important step in minimizing a person’s exposure to stress specific to commute mode choice.

Data collected for this research includes surveys administered to companies that have employee access to vanpool service in addition to other forms of public transportation. Focusing on commutes in different areas of the State of California allowed the study to compare commutes that shared similar issues (congestion, suburban-to-urban and urban-to-urban routes, weather conditions, etc.).

A similar study from the University of California Los Angeles (UCLA) was conducted in 2015. In that study, the researchers interviewed a selection of the institution’s vanpool participants to reveal their perceived benefits of using a vanpool. The study included respondent information from recorded statements and determined that riders in every group indicated that participating in the van was a source of dramatic reduction in stress (7). This study’s findings concur with those statements through statistical analysis. These perceptions can account for outcomes from earlier research specific to vanpools where an EPA study found that over 90% of all employees who have participated in vanpools intend to stay in them (8). It could benefit the MaaS industry to understand why satisfaction of utilizing this mode leads to a desire to continue with that behavior.

RESEARCH ADMINISTRATION

For each individual site, an informed consent letter was sent to the population one week in advance of the first survey being sent. This allowed for proper review of the consent page, and an opportunity to ask the research team questions. The surveys began the following Monday and were sent at five a.m. and five p.m. each day for the 14 day period.
Survey Research Tools

After the survey questions were developed, a crosscheck was performed to ensure the questions were appropriate to the intended outcomes, and to make sure they were easily understood by the average commuter. The survey medium was the Qualtrics™ online platform that was chosen instead of a mobile based survey tool because all of the employers participating gave permission to allow employees to use the internet during their work day to complete the survey. Each employer site was provided with a set timeline to expect survey participation.

Survey Implementation

This research was limited to employers in the State of California. To set an accurate baseline, it was important to ensure the respondents are experiencing approximately the same issues during their commute. California commutes are universally congested, especially in the cities—specifically the employment centers where the research was targeted. The surveys were performed electronically at employers in the cities of San Mateo, Los Angeles, and San Francisco, California. Locations were chosen based on the willingness for cooperation by an in-house administrator; population size (medium and large employee sets); and existing vanpool users.

The sites that received the surveys included: Los Angeles World Airports™ (LAWA), LinkedIn™, and Intuit™. These sites each met the criteria for a willing site administrator, and all have existing vanpool participation. Each of these locations is within a city in the State of California.

Analysis Tools

Upon completion, each individual survey was downloaded from its submission date, and aggregated according to survey type (morning or evening). Once the individual site information was inserted into individual Excel™ spreadsheets, descriptive statistic information was derived utilizing the Excel add-in. The descriptive statistic data was then used to perform confidence intervals which are described in detail later.

Understanding the Results

Each of the individual result sets had a total number of people who signed up during the informed consent period. However, on any given day, fewer than the total number of people that registered actually submitted their survey information. It is also important to note that an individual could take a vanpool one way and a bus the other way, or any other number of choices based on their daily routines. Each day respondents were asked to proceed with their surveys only if they actually commuted by one of the selected modes. This means if they used any other mode (such as bus, carpool, etc.), that information is not logged in this dataset because these respondents were taken to the end of the survey. The ability to choose “other” is also why the totals for percentage of SOV and vanpool vs. the total number of responses do not add up to 100%.

Additionally, it is acknowledged that stress levels may differ based on the roles of drivers and riders, trip length, and between gender and age groups. When all SOV driver stress ratings were aggregated, there is no substantial difference between the reported changes in the male and female SOVs. Although male drivers start with a lower reported average stress level of 3.09 versus the female average of 3.22, both show a 21% increase in stress after the commute. However, there are substantial differences in the vanpool groups’ reporting of stress based on role and gender. Male vanpool drivers reported increased stress levels of 18% after the commute compared to just 3% increase in stress reported by female vanpool drivers. Conversely,
male vanpool riders reported a 13% decrease in post-commute stress, while female vanpool riders only experienced a 5% reduction in stress. The delta between male SOVs and male vanpool riders is a 34% difference in stress level, while the delta between female SOVs and vanpool riders is 26%. From these findings, it would appear that the male SOVs may experience a greater benefit in stress reduction by changing modes. The group with the highest stress levels both before and after the commute was female vanpool drivers, who reported 4.33 before the commute and 4.45 after the commute, an increase of 3%. The group with the lowest reported stress level before the commute was male SOVs at 3.09, while the group with the lowest reported stress level after the commute was male vanpool riders at 2.87.

The trip length significantly affected reported stress levels of all groups. Female SOVs showed the greatest delta in stress level by distance with an increase of 3.31 between the group traveling 25 or less miles (-0.51) and the group traveling 50-69 miles (-3.81). This is an increase of 655%. Male vanpool drivers showed the highest percentage increase in stress by distance of 967% difference between those traveling 0-25 miles (-0.9) and those traveling 50-69 miles (-0.91). The groups least affected by trip distance were male and female vanpool riders. Those traveling 70 or more miles actually showed an improvement in stress levels, indicating that the longer drive may have a calming effect, or could indicate an acceptance of the task at hand more than the shorter distances may experience. Further research is recommended to explain this unique outcome.

On any given day the number of respondents fluctuated based on the mode choice they used that day. For purposes of comparing the data, the average number of respondents was used for the length of the study for the morning report, and separately for the evening report. There is potential for bias in the data because the total number of responses on any given day will differ, affecting the sample. However, as a way to minimize this issue, the survey was administered for a total of 14 days as a way to increase the likelihood that individual responses would be repeated a number of times and maximize the opportunity for highly reliable data.

Each site observed a significant drop in the number of total respondents for both the vanpool and SOV categories on weekends. The drop in responses was common at each site. If the data were analyzed in that manner there would be weighted bias in the outcome of the individuals who did log any data on those days. In order to keep the dataset more reliable, the Saturday and Sunday responses were removed entirely, and instead analysis was performed only on days one through five of each survey week. Many work locations have schedules that operate seven days a week, and therefore all weekday as well as weekend data was intended to be included. Future follow-on research could identify in advance if a seven-day schedule is common before requiring those dates in the response set. All outcomes list days one through ten for surveys, which correlate to Monday through Friday of both weeks studied.

Individual Site Information

Los Angeles World Airports™

Los Angeles World Airports (LAWA) was the first survey administration site. One hundred eighty-seven employees signed up during the informed consent period. LAWA's employees were highly engaged throughout the process. On average, there was a total of 88 responses in the morning and 84 responses in the evening. The percentage of vanpool responses in this total was 25% on average for both the morning and evening. The percentage of SOV responses was 68% in the morning and 69% in the evening. Overall, the percentage of responses was the same from the morning to the evening. During survey analysis, LAWA was able to confirm the percentage of the sample of SOV and vanpool participants was consistent with their population.
In cooperation with this research, LAWA provided additional data to enhance the overall outcomes. The additional data is specific to LAWA only, and provides insight into metrics that are significant to them as an employer. Though this data did not come from the originating research, the outcomes provided by LAWA are included here because it pertains to the same population that the research sample was derived from. The additional analysis focused on how vanpool participation relates to attendance. Specifically this company has an annual award program for employees who are able to achieve Good or Perfect Attendance. These awards include a certificate of achievement placed in the employee’s personnel file and a small cash reward. Good Attendance requires an employee to have 3 or less unscheduled days off during the year, while Perfect Attendance allows for no unscheduled days off.

LAWA collected Vanpool participation and attendance data at Los Angeles International (LAX) Airport for 6 years from 2010-2015. During those years 14-15% of LAX employees were participating in the Vanpool Program, and 17-20% of employees achieving Good or Perfect Attendance ratings were vanpoolers. This showed a correlation between vanpooling and attendance at an average of 3.4% higher than non-vanpool commuters over these six years.

During this period, 25.5% to 31.7% of vanpoolers achieved good or perfect attendance ratings each year at an average of 28.6% of vanpool participants per year. For comparison, 23.4% of employees in all travel modes and 23.3% of solo drivers achieved this honor, showing that vanpoolers earned attendance awards at a rate 5.4% higher than the general population.

Additional research should be conducted in this area to determine the exact reasons for the correlation between vanpool participation and improved attendance. It would be beneficial for companies to quantify this data further, perhaps by calculating loss of revenue due to employee absence. It could be an important metric for the business case behind offering Mobility as a Service options in that paying for some level of service could offset losses due to absenteeism, or realized savings in healthcare costs due to lower stress levels as indicated in the overall findings.

LinkedIn™

During the informed consent period, 130 individuals signed up. A daily average of 42 individual responses were registered. Of the morning responses, an average of 8% of the total responses were from vanpoolers, whereas 66% were SOV commuters. The evening commutes registered similar data: 9% of the total were vanpoolers and 63% were SOV commuters. The much smaller ratio of SOV to vanpool responses could be cause for concern. A discussion with the site administrator confirmed that the ratio of vanpool to SOV commuters was representative of their overall population.

Intuit™

During the informed consent period, 204 individuals signed up to participate. Initially, the sample size reflected a mix of 12% vanpoolers to 88% SOV commuters. The site administrator was contacted and confirmed that it was appropriate sample size. By the close, surveys averaged 66 respondents per day. Of the daily responses, 10% were vanpoolers, and 76% were SOV drivers, making the overall averages representative of the population of the chosen site, as confirmed by the site administrator.
SUMMARY FINDINGS

Confidence intervals (CI) estimate the mean of the dataset using the desired level of confidence coefficient, which in the case was chosen to be 95% (CI95). After performing several confidence interval analyses and reviewing the descriptive statistics (as well as other statistical tools) the data analysis outcomes support the conjecture from the Mobility as a Service industry that vanpools do in fact lower stress. Each statistical tool answered specific questions relating to the data itself, and including CI for paired data, independent means assuming population variances, and proportions. There were 5,515 individual responses received, including the morning and evening commutes. In all, 1,986 individual surveys were analyzed for the morning commute and 1,813 individual surveys analyzed for the evening commute. The respondents included 70% SOV and 16% VP commuters (Figure 3).

These averages are consistent with the anticipated average SOV versus vanpool commuter as reported by each survey location chosen. The formal conclusion of this study is that SOV commuters have higher levels of stress than VP commuters after the commute in both the morning and the evening. The resulting data did not show a normal distribution, however, the vanpool data is consistently to the left of the SOV data. Since the data was not normally distributed non-parametric tests (Wilcoxon Rank Sum Tests) were run in addition to the parametric confidence intervals. The non-parametric results reflected p-values that were near zero which indicate that the original parametric method was appropriate, as well as simpler to express in the findings. All confidence intervals assume the samples reflect the population. There is no indication that they do not. The findings suggest a link between choice of commute mode and overall average stress level.

Over the term of the study, vanpool commuters reported 21% less stress than the SOV commuters on a daily basis. Breaking down that number, vanpoolers reported a 5% decrease in stress, while the SOV commuters reported a 16% increase in stress, which is a combined total of a 21% difference.

On average, vanpool commuters were shown to have a slightly higher (though not statistically significant) level of stress than their SOV counterparts before the commute. However, by the end of the commute the same group reported a statistically significant lower level of stress than its original score, and a significantly lower reported level of stress than the SOV commuter group. The evening commute vanpool participants showed a (statistically significant) higher stress level before the commute compared to the SOV participants,
which actually lowered after the commute. Conversely, the SOV commuters stated a lower level of stress than the vanpool commuters before their commute, and experienced a higher level of stress at the end of their commute (Figure 4).

These findings support the outcomes from the confidence intervals and show a correlation between the data, with the only change occurring over the period of time being the commute itself. These findings support a relationship between commute choice and stress level. The data reveals a logical association between commute and stress levels, with vanpoolers experiencing lower levels of overall stress compared to single-occupant drivers as a result of their commute choice.

**Confidence Intervals (CI)**

The first methodology applied to the dataset (CI paired data) was used to determine whether there is a statistical difference between each mode-specific user group before and after their commute, with respect to both the morning and evening commute. The same people assessed themselves before and after the commute, therefore allowing for a degree of control over the variability of the results. For the morning commute, VP equaled no statistical difference between average stress levels before and after. The level of stress experienced before the commute remained the same at the end of the commute. SOV equaled on average (.69-1.04) CI95 more stress on the scale after the commute than before. For the evening results both modes showed a change before and after in slightly different ways. VP = an average (.25 to .74) CI95 change reporting less stress upon arriving home than when leaving work. The commute appears to play a role in the reduction of stress when using a vanpool. SOV = an average (.25 to .54) CI95 increase in stress after arriving home than when leaving work. Hence, the commute for the SOV group had a higher post-commute stress level, while the VP group experienced lower levels.

The second methodology applied to the dataset (CI independent means with different variances) was used to determine if there was a statistical difference between VP and SOV with respect to the delta in stress levels.
before and after their respective commutes. It acknowledges that there will be an expected change in stress for either method, but answers whether one mode has a greater level of change over another. The morning results show average stress levels were greater (.4 to 1.0) CI95 for SOV than for VP. Though both methods indicated an average increase in stress, the SOV commutes produced a greater differential. As in method one, method two reflected major differences in the evening data. Average stress level changes were greater (.66 to 1.18) CI95 for SOV than VP. Both indicated an average increase, but the SOV mode produced a greater differential in stress. Interestingly, the VP mode reported that on average, the VP commuters ended their commute with lower stress than when starting. This reiterated previous findings.

The third methodology applied to the dataset (CI independent means with different variances) compared the actual self-assessed test scores rather than the changes in stress levels between VP and SOV. This measured the statistical difference between “before” commute for both VP and SOV. It would indicate whether there is one group that is inherently more prone to stress than the other, hence any differences that could be attributed to lifestyle rather than the commute. For the morning results there was no statistical differences before the commute between VP and SOV. Both types had the same initial stress. After the commute the SOV has between a (.14 and .88) CI95 greater average self-assessed stress level than the VP counterparts. For the evening commute the “before” level of stress comparing the modes showed that VP showed a (.18 to 1.00) CI95 average higher stress level. This result is counterintuitive. A possible explanation could include anxiety of the impending commute to be sure they get to the van on time for departure. Further research would be necessary to explain this higher stress level at the end of their day. The “after” commute data reflects no statistical difference between the modes. This may appear strange, however there are reasonable explanations to explain this result. The first findings show a higher initial stress level for VP that appears to be overcome by the commute itself. The higher initial result appears to either mitigate stress for the VP while increasing for the SOV as the commute progresses. Looking back on the data from the second methodology applied, it appears as though a combination of decreased stress for the VP and an increase in stress for the SOV produces the result. It should be noted that the average difference for VP shows a .52 differential decrease in stress between the start and finish for VP. Conversely, there is an average .40 differential increase in stress for the SO commuter. Vanpool is the only group to show an actual decrease in stress level as a result of the commute.

The fourth methodology applied to the dataset (CI proportions) asked what the differential in proportion between VP and SOV was, with respect to the before- and after-commute delta of the stress level. No additional stress or a reduction in stress would be data of importance. Only the delta with respect to no change, or reduction from pre- as well as post-commute is counted to determine the proportion between the two groups. Morning results show an average of (18 to 55%) CI95 VP users had either no change in stress or reduced stress compared to their SOV counterparts. For the evening, there is an average of (47 to 85% CI95) VP users who had either no change of reduced stress levels compared to the SOV.

The fifth methodology applied to the dataset (CI proportions) ignores any difference between the morning and evening commutes, and determines the overall difference in proportion between VP and SOV with respect to commute stress. This is a combination of all the differential data. A negative score means that stress increased. A positive score means that stress decreased. A zero score means there was no change. The positive and zero scores were counted for the VP and SOV groups using 60 as a divisor (total count). On average, between (37 to 66%) CI95 VP users had no change in stress or reduced stress compared to their SOV counterparts.
Performing five different confidence intervals was a way to ensure the individual actions were replicating results of the overall findings. The mean identified through the descriptive statistics was then used to compare the high level findings and reflect the actual reduction (as observed in the vanpool results) with the increased stress level (as observed in the SOV results).

OVERALL OBSERVATIONS

The evening commuters appeared to be better with regard to stress than the morning commuters. Future research should focus on explaining a commuter's ability to handle stress at the end of their day better than at the beginning of it. The only category of commuter that resulted in less stress after their commute was the evening vanpool group. This could be an important behavioral marker to note; the vanpool group was able to start their evening at home with lower stress, which could be beneficial to the individual; further research is required to understand why. All other categories showed an increase in stress after the commute. It is important to note that in the morning although both categories reported an increase, the vanpool group’s increase was minimal. Other than the “within VP and SOV CI,” all other applied methodologies were conducted assuming unequal population variances. In order for the outcomes to have broader applicability, future research should expand to areas outside of California to determine if the outcomes are consistent.

Healthy Stress Levels

The American Psychological Association “Stress in America” study shows that in 2014 the Average American level of stress is 4.9 on a scale of 1-10. The level of stress that those same individuals felt on average would be a healthy level of stress is 3.7 (9). This would require a reduction of 1.2 points, a 24% reduction of their stress level, to achieve what respondents perceive to be a healthy amount of stress. What combination of changes would account for that much change to achieve the targeted stress level? It would appear that there is an opportunity to assist in identifying ways that the average American could reduce their levels of stress. Utilization of vanpools or SOVs appears to be a contributing factor to either an increase or decrease in stress level. Further research is necessary to identify if these results can be replicated against other modes of transportation. As an overall goal of making healthy choices, determining a commute choice that supports stress reduction would be a good strategy.

Closing Remarks

A study performed by the Transportation Research Board (TRB) from the United States determined that both demographic variables and attitudinal factors are important and significant in explaining mode-choice behavior (10). The many questions raised as a result of this study, such as “what other contributing factors could explain the difference in stress before and after the commute?” or “will other modes of transportation reflect similar reductions?” etc. reaffirm a need for ongoing research in commuter decision processes. Future research should account for additional perspectives including a study on stress before joining a rideshare arrangement and then measured afterward. Such future research if commissioned by a governmental agency could diversify the dataset by including more regions of the U.S. and Internationally. Understanding the underlying factors that allow certain individuals to choose one transportation mode over another can assist the field of MaaS in making educated choices for their service networks. This study provides a unique perspective into potential (perhaps even unrealized) motivating factors for vanpoolers as well as single occupant drivers.
REFERENCES

Can we Design Mobility Services accounting for Complexity and Social Justice?

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ABSTRACT

Recent convergent development of sensing, computation, and communication technology is enabling the advent of self-driving vehicle (SDV) technology. Moreover, general advances in digitalization and smartphone use are enabling the advent of mobility services, exemplified in a Mobility as a Service (MaaS) concept. Considering the potential societally-wide disruption stemming from SDV technology and MaaS, a need arises for simultaneously considering the development of mobility technologies and services. In the spirit of Value Sensitive Design, as socio-technical systems, mobility system design has to account for underlying behavioural aspects alongside the technological interdependencies. Moreover, in the spirit of liberal theory of justice, mobility system design has to account for how advantages and disadvantages will be distributed among users. The objective of this research is to provide a proof of concept for possibility of such a design approach. The basis for this research is a version of Priority System (PS), developed as integrated mobility and traffic management framework. Based on the explicit formulation of complexity and social justice requirements, PS provides an opportunity for the user to select a Priority Level for her trip, in addition to destination and route. Moreover, PS includes a scheme of non-monetary Mobility Credits, and has a direct relations for SDV control at the intersection, route, and network level. In addition to elaborating PS, in order to evaluate the prosed concept, we have used a web-based experimentation with human subjects interacting with a version of PS. Thus, this paper focuses on development of web-based experimentation for allowing user interaction with PS. In addition, this paper will present the information collected from web-based experiment. Findings include in-depth insights into human decision-making within the proposed mobility management framework. In addition, the paper presents a summary of respondents’ comments related to proposed management framework and technology in general. Finally, the paper presents a summary of results, conclusions, and recommendations for further research, emphasizing upon the need for understanding human decision-making and potential in using web-based environment for further participatory development of both SDV and MaaS technology.

KEYWORDS Self-Driving Vehicles, Mobility as a Service, Traffic Control, Social Justice, Web-Based Experiment, Value Sensitive Design
INTRODUCTION

With the ongoing development of self-driving vehicle (SDV) technology [1, 2], there is a range of questions that emerges too. Considering that in the last stage of development, SDVs will be able to perform all safety-critical driving functions and monitor roadway conditions for an entire trip, the current vision is that user’s responsibility will be limited solely to destination and navigation input [3]. As a result, SDV technology could improve traffic safety [4], improve the mobility of people unable to drive [5], mitigate the environmental impacts of automotive transportation [5], and increase operating capabilities from road infrastructure [6]. With the simultaneous development of SDV technology, we also see a range of efforts in development of Mobility-as-a-Service concept and technology.

However, the vision for these mobility technologies primarily focuses on potential benefits (e.g., [6]), underestimating the complexity of technological evolution. One important point that technology designers might not be aware is that, as other technologies [7-9], transportation technology evokes and influences user’s behavior. In addition, focusing on assessing how efficiently technology achieves its operational goals, might neglect how responsive technology is to social, moral, and political values [10, 11]. Considering that both SDV and MaaS technology are in their foundational stages of development, this is a crucial stage allowing us to rethink some fundamental premises and develop a sustainable technology – technology that can fulfill our current needs but not restrict the needs of the future generations [12, 13]. With this in mind, the approach presented here will be analogous to the Value Sensitive Design approach [14-16].

The core value taken into consideration in this research is social justice. In essence, social justice refers to the structure that determines how advantages and disadvantages from certain technology are distributed in a society [17]. We have based our consideration of social justice upon a theory proposed by John Rawls [18]. Consequently, mobility management framework has been developed as a version of Priority System (PS). This PS allows the user to select a Priority Level (PL) for their trip with SDV. A general idea is that each vehicle is supposed to use their PL and in communication with other SDVs at an intersection, can determine who receives the right-of-way. Although there have been several previous research efforts for developing traffic control mechanism for SDVs (e.g., [19-21]), this is the first attempt to enable end-user responsibility in the management process.

Considering that initial development of PS is presented in a different paper, this paper will focus on web-based experimentation for allowing user interaction with PS. In addition, this paper will present the information collected from web-based experiment to develop simulation scenarios and consequently evaluate PS operation at an isolated intersection. First, we will present our methodological approach, followed by details of the web-experiment development. In addition, this paper will present results from web-based experiment. Finally, the paper will present a summary of respondents’ comments, followed by conclusions.
METHODOLOGY

Priority System

As argued elsewhere [22], mobility management technology in general directly affects following universal
and fundamental human rights [23]:

1. right to life,
2. right to freedom of movement, and
3. right to equal access to public service.

Considering that these rights are universal and fundamental for every human being, as prerequisite for
carrying out life’s plans, it becomes an imperative for mobility management technology not to promote an
unjust distribution of restrictions to these rights. This is why an underlying framework of social justice within
mobility technology is an important point to consider. Consequently, there is a relation to a management
objective, and in this case we relate it to travel time or delay per user.

John Rawls has developed his theory based on the principles of liberty and equality. Essentially, Rawls’
framework is arranged to protect the inviolability of the user and maximize the benefits of the least advantaged
in the complete scheme of equally shared by all [24]. Rawls’ principles have been used to structure a framework
for development of new technology. Considering that the inviolability of the user is the most important point
in this framework, this can be translated as emphasizing the distribution of delay among individuals, and
not solely emphasizing upon the total delay for an approach, an intersection, or the whole transport system.
In order to protect the inviolability of the user, management principles are developed to allow for greater
responsibility of end-user in the management process. Enhancing end-user responsibility is envisioned to
emphasize long-term and large-scale cooperation for the mutual advantage of individual user, and to support
a just structure. In addition, such a mobility management framework has to account for complexity of human
behavior, especially in the context of preventing user usurpation. Thus, we have primarily focused on human
tendency to cooperate [25], especially in cases with reciprocity [26, 27], because people care about outcome
for other people and greater social goals [28, 29], if they perceive that other people cooperate [30], if there is
reputation building [30] or sanctioning system [25].

At this current stage of development, within PS, a user can select a PL for each trip, in integer value from one
to four. These PL is then used to determine the right-of-way between SDVs approaching intersection, where
SDV with the higher PL has the right-of-way over the SDV with lower PL. Consequently, PS is similar to the
priority queuing principles [31], where a user is selected for service if it is the member of the highest priority
class. However, the users within a class are selected upon FIFO principle. For example, one person would
assign “very high priority” one day, due to the emergency that trip has (e.g., trip to the hospital). The other
person for the same day would assign “low priority” since the trip has leisure as a purpose. In the case when
these two vehicles approach the same intersection at approximately similar amount of time, the vehicle with
“very high priority” would be the first one to receive right-of-way, relative to the vehicle with “low priority”.
The users in this situation might have respectively inverse roles in other situation, and would achieve the
respectively inverse result. This is underlying an agreement between vehicles in a system of cooperative
production – person A will yield to person B today when person B needs right-of-way, under agreement that
person B will yield person A tomorrow, when person A needs right-of-way.
However, in order to avoid user usurpation of the PS, there has been developed a system of non-monetary Mobility Credits (₡). In the initial assignment, each user should receive identical amount of 20 ₡. Spending/gaining of ₡ relates only through PL selection, with uniform rules for all users (Table 1). In addition, there is a ₡ ceiling, being a maximum number of ₡ that individual user can have. In addition to these rules, there is a series of other rules proposed elsewhere. Considering that this is the initial development stage, the research team has decided to implement the simplest version of PS to potentially obtain greater insight about a potential range of issues. Details on the control framework model are presented in [32-35].

<table>
<thead>
<tr>
<th>PL</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>₡</td>
<td>+2</td>
<td>0</td>
<td>-2</td>
<td>-10</td>
</tr>
</tbody>
</table>

Table 1: Initial ₡ system in relation to Priority Levels

Methodological Approach

For the research approach, the research team has decided to use web-based experiment. Web-based experiment is selected because of faster speed, lower cost, greater external validity, the ability to experiment around the clock, high degree of automation of the experiment leading to low maintenance costs and limited experimenter effects, and wider samples than in person experiment [36]. Moreover, comparison of web-based experiments with in person surveys have showed similar results [37]. For example, Gosling et al. found that internet samples are relatively diverse with respect to gender, socio-economic status, geographic region and age; that findings were not adversely affected by non-serious or repeat responders; that findings are consistent with those from traditional methods [38]. Similarly, Meyerson and Tryon conducted a study to evaluate the psychometric equivalence of online research, and concluded that data gathered was reliable, valid and reasonably representative, as well as noting that the process of gathering data was cost effective and efficient [39]. However, there are comparisons which have shown differences. Dandurand, Shultz and Onishi found that online participants were less accurate in their performance of tasks than lab-based participants completed their task less accurately than their lab-based participants, they attributed it to the possibility that online participants may have been simultaneously working on other things or have been distracted while completing the task [40]. With this in mind, the design of this web experiment will specifically focus on attracting and maintaining attention of the participant.

WEB-BASED EXPERIMENTATION

Experiment Setup and Development

For user experiment, research team has decided to develop a custom website (approved by Institutional Review Board VT IRB 14-542). The purpose of web-experiment was to collect information on user decision-making within PS, and opinions related to PS. Experiment was anonymous and subjects had to be over 18 years old to participate. In total, the experiment was developed not to require more than 10 to 15 minutes of time commitment. Since it is web-based, experiment can be performed at any location with Internet connection. Information from the experiment was collected in a database on a secure server. In addition, the website is stored on external service with Secure Sockets Layer (SSL) encryption. Hyperlink for experiment was distributed via Virginia Tech news, listservs, and using LinkedIn website, mostly on groups related to transportation or autonomous vehicles. In addition to root page, where subjects starts the experimental process, there were five more pages: consent, info, experiment, exit, and contact page.
As already mentioned, web-based experiment provides respondent with autonomy and convenience for participating. However, previous research recommends that other elements are incorporated (e.g., shortness of experiment, shortening loading times, interesting content, emphasizing contribution, etc.) [41]. Recommendation is that website needs to have aesthetic quality, convey trust in online entity, has interactive elements, simplified instructions and extroverted writing style. Moreover, design needs to take into consideration elements such as font size, color, ability for normal reading, expected location of the content, etc. [42]. These design elements were implemented throughout the website pages. Finally, the user can enter a raffle for a chance to win a $50 gift card or can provide their name and approximate location for a list of contributors that will be publically listed on the experiment's website. The diagram of web-page structure and diagram of user activities and decision-making steps during an experiment are presented on the left and right side of the following figure, respectively.
Figure 1: Diagram of web-page structure and diagram of user activities and decision-making steps during an experiment
• Consent page
On the first web page (top left part of Figure 2), similar to a consent form, subject was presented with information on the study purpose, who is conducting the study, expectation from the participant, risk, benefits, anonymity and confidentiality, freedom to withdraw, and contact info [43]. This page is intended to emphasize confidentiality, and to include information that will increase trust in researchers [41, 44]. Self-disclosure has been done using LinkedIn profiles from research team members to establish rapport. In addition, it was important to include information on how long the experiment will last, and that participant’s contribution will affect the design of technology [45]. Finally, participants are also asked to provide consent at the end of this web page by clicking on the button for Info page.

• Info page
After providing consent and continuing to the info page (top right part of Figure 2), subject is presented with detailed information about the operation of Priority System, and trip parameters for decision-making in the web experiment.

• Experiment page
On the third page (lower left side of Figure 2), the participant is supposed to interact with the management framework. Participant is expected to select PL based on information about his/her hypothetical trips and ₡. In addition, participant can provide information on his/her reasons for decision to select a specific PL. Subject can be involved with the experiment as long as they prefer, and as many times as they prefer. The limit of minimum 10 interactions within one experiment is set to be eligible for entering the raffle. Considering that even the design of PL selection button can affect user’s decision-making [41, 44], research team decided to use radio button since it provides the simultaneous visual overview of all PLs. In addition, PL 4 or PL 3 buttons would dynamically disappear, based on the number of available ₡. The button “Next trip” was used to provide the participant with the information about the next hypothetical trip, and to store previous PL selection and comments. In addition to this button, there is an “Exit” button, used to lead participant to an Exit page. This is preferred option, since participant can be debriefed about the experiment, and prevented from simply closing the browser tab and leaving the experiment [45].

In addition, trip parameters used in the experiment, along with their distributions and values, is presented on Table 2. Trip purpose distribution has been approximated from National Household Travel Survey for 2009 [46], taking into consideration respective frequencies between different trip purposes. Based on the interviews, time obligations are divided into three categories, as without time obligation, with time obligation, and with strict time obligation (Table 2). In addition, there were estimates of time delay per trip purpose (Table 2), which were also as time obligation approximated from previous interviews with users. For web development of experiment mechanism, research team used PHP, general-purpose scripting language [47]. Specifically, for generating random numbers, `rand`, a PHP function that generates random integers between certain interval [48]. Finally, every time any user follows the webpage link, new user id is assigned, thus allowing different users to anonymously participate in the experiment several times.
### Table 2: The distribution of trip purpose, time obligations, and time delay

<table>
<thead>
<tr>
<th>Trip purpose</th>
<th>Distribution</th>
<th>Time obligations (uniformly random)</th>
<th>Time delay (uniformly random)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shopping</td>
<td>20%</td>
<td>W/o</td>
<td>20</td>
</tr>
<tr>
<td>Holiday</td>
<td>8%</td>
<td>W/o</td>
<td>40</td>
</tr>
<tr>
<td>Social</td>
<td>17%</td>
<td>W/</td>
<td>20</td>
</tr>
<tr>
<td>Entertainment</td>
<td>5%</td>
<td>W/</td>
<td>15</td>
</tr>
<tr>
<td>Personal</td>
<td>19%</td>
<td>W/</td>
<td>15</td>
</tr>
<tr>
<td>Work/school</td>
<td>29%</td>
<td>W/</td>
<td>15</td>
</tr>
<tr>
<td>Medical</td>
<td>2%</td>
<td>N/A</td>
<td>5</td>
</tr>
</tbody>
</table>

- Exit page

After experiment page, user can reach exit page (lower right side of Figure 2). Remembering that attracting participant’s interest are crucial issue with web-based experiment, experiment design included an option for users to submit their email for a raffle after a certain number of experiment iterations, and to submit their name and approximate location for public announcement of contribution. Research team decided to use online gift-certificates so that subject can redeem their certificate without revealing their identity. In addition, on the final page of the experiment, subject will also have an option to provide his/her opinion related to Priority System, as a part of debriefing from experiment page.

- Contact page

Finally, from each web page, the user has an option to contact the research team, for questions or to report a problem [45].
Web-based Experiment Results

After closing the web experiment, there has been total of 266 participants. Minority of participants provided less than ten or more than 100 PL selections (maximum is 350 PL selections), with an average of 34.1 PL selections and median of 20 PL selections per participant. In reality, PS is envisioned for long-term interaction, so experiment results present only a part of the potential number of situations. Consequently, behavior of participants might be primarily short term, and relying on their imagination to consider their decision-making in specific situations. Considering that experiment results were stored in a database, research team has used SQL queries to extract and group results.

Following several figures (from Figure 3 to Figure 9) show the number of selections of each PL for different trip purpose, and varying by time obligation and expected delay. From these figures we can observe user tendency to select certain PL depending on the trip purpose, time obligation, and expected delay. One can also observe a shift from tendency to select one PL to tendency to select other PL as trip parameters change. First, one can see that user tend to select lower PL for shopping, social, entertainment, vs. holiday, personal business, work/school, and medical trip purpose. Second, one can notice that users tend to select lower PL if the estimated delay is negative vs. when estimated delay is positive. Similarly, for time obligation, users tend to select lower PLs when there is no time obligation, as opposed to trips with time obligation.
Figure 3: Number of selections of PL for shopping trip purpose, varying by time obligation and expected delay
Figure 4: Number of selections of PL for social trip purpose, varying by time obligation and expected delay
Figure 5: Number of selections of PL for entertainment/sport trip purpose, varying by time obligation and expected delay
Figure 6: Number of selections of PL for holiday trip purpose, varying by time obligation and expected delay
Figure 7: Number of selections of PL for personal business trip purpose, varying by time obligation and expected delay
Figure 8: Number of selections of PL for work/school trip purpose, varying by time obligation and expected delay
In addition, Figure 10 shows number of PL selections per PL and based on the available ₡ for the user. One can observe that most of the selections were done at 24, 22, and 20 ₡, but that users were selecting at all ₡ values. However, selection of PL 4 does not occur at below 10 ₡, and selection of PL 3 does not occur at 0 ₡. In addition, the ratio of PL selected is similar for great majority of available ₡ values, where the frequency of PL selection is inverse to PL value.

Participant 64 is an example of risk averse user, always trying to remain around maximum ₡. Participant 7 is an example of user trying to remain above 10 ₡, as a critical value for selecting PL 4. Finally, participant 59 is an example of user that covers a wide range of ₡ values. The last type of the user tells us that there might be influence from shortness of the experimentation period, since participants might not be immediately focusing on ₡ saving.
Figure 11: Examples of PL selected in relation to Priority Credits available
Further analysis shows that, from 8311 PL selections, 392 of these selections (4.7%) were at 0 ₡. Having in mind that the framework was envisioned to deter users from reaching 0 ₡ (since user cannot select either PL 3 or PL 4 at that point), this is not a significant percentage of situations. Consequently, we can conclude that only a small percentage of participants was not assuming interaction with PS on a long-term basis. However, there is a learning process involved when users arrive to 0 ₡ in long-term system operation, that could potentially resulting in better ₡ management after the initial period. In addition, average PL selected was 1.8, while median PL selected was 2, confirming previous observation that participants mostly tend to select PL 1 and PL 2. This was the intention of the framework, thus deterring the overuse of higher PLs.

Web-based Experiment Comments

In addition to PL selection, there are comments that participants provided during PL selection, and on the Exit page. They are organized into following five groups.

1. Positive features
   - Ability for user to prioritize and use highest PL for emergency situations.
   - PS is forcing users to think about their choices and to plan ahead their time.
   - PS deters abuse (e.g., with the maximum limit for ₡, high ₡ value for PL 4).
   - Fair ₡ distribution and ability to save.

2. Potential for system failure
   - Concern from self-centered human nature and differences in evaluating different PLs that might lead to inflated sense of urgency and frequent selection of higher PLs.
   - Favoring individuals with more education, planning or management skills.
   - Remaining without ₡ but facing an emergency situation.
   - Using meaningless and short trips to accumulate ₡.
   - Alternating between assigning PL 1 and PL 3.
   - No incentive to select PL 1 once ₡ are at 24.
   - Users that do not drive much could use higher PLs more often.
   - If an area simultaneously accommodates many users with medical conditions or appointments, where users assign high PLs all the time.
   - Incentive to spend ₡ when a user has them.

3. Further development
   - Priority credits should be tied to an individual instead to a vehicle.
   - PL should be adjustable during the trip, as the need arises.
   - Highest PL should be only activated by external mechanism (e.g., calling police).
   - PL should be assigned and ₡ lost/gained based on destination and arrival time needed.
   - There should be a mechanism for post-activation verification for highest PL and for spending/gaining ₡ (e.g., medical emergency).
   - There should be a separate emergency ₡.
   - There should be different mechanism for gaining ₡ (e.g., reporting incidents, using zero emission vehicle, using active or public transportation).
The importance of PLs should be inverse (PL 1 being the most important).
PS should be combined with trip information service to reduce system abuse.
There should be minimum distance or minimum amount of time SDV needs to be stationary for receiving C.
There should be maximum number of C user can gain during certain time.
Medical emergencies should not cost C or there should be
Low PL trip with no conflicts at an intersection should not gain C.
PL should be determined by someone who is unbiased (e.g., third party customer representative).
User should know in advance how long it will take to travel with each PL.
Route, speed, or road lane for SDV could be determined based selected PL.
There should be an option for combining several PLs and their C for carpooling.
There should be three or five PLs, without PL that does not lose or gain C, or with higher max C but along with higher C loss for selecting higher PLs.
Activation of highest PL (or separate emergency PL) should drive SDV to the nearest hospital, with fines for misuse.
PL 4 should only be available for selection if SDV’s destination is on the predefined list (e.g., hospital).
Gain of C for lowest PL should have higher value.
PS should be setup differently for delivery vehicles, taxis, or infrastructure support vehicles (e.g., more C, less PLs).
Loosing and gaining C based on the number of C that user has (e.g., as C number increases, gaining less C).
People that need frequent medical care or voluntary firemen should have more starting C.
There should be monetary component related to PLs or C (e.g., either as paying, exchange for bitcoins, or as market).
Further development will need to take into consideration local culture, values, etc.

4. User factors

Estimated arrival at destination (e.g., depending on departure time or trip duration)
Value of time punctuality and consequences
Culture and habits (e.g., value of time, acceptance for being late to social events vs. doctor’s appointment, level of relationship, ability to call ahead, ability to “blame it on traffic”, understanding for repeated lateness to social events because of other obligations, acceptable arrival window for activity, dinner reservation, being always late for social events)
Relative importance of the destination/activity (shopping low, plane important but not as emergency)
Other people involved or in the vehicle
Next obligation (e.g., shopping might not be important, but might become based on the next activity)
Time available in the day
C (e.g., being around 10 C as a critical value for selecting PL 4, intention to save or gain C)

5. General points

Concern about mechanical failure, hacking, and illegal market for buying/selling priority credits
Perception of transportation as a service and “selling” arrival on time
• Complexity of trip in time and space and relation to PLs (e.g., higher PL does not mean getting somewhere faster)
• Not losing inherent flexibility in human driving
• Getting used not to have control over the vehicle and the issue that removing a sense of agency from driver that is late can increase stress level
• People do make distinctions between different trips within the same trip purpose – holiday trip to the lake and one that involves taking a plane are not valued equally
• An opinion that an expert system would work better
• Reevaluation of travel time with impact from SDV technology
• Perception that automated vehicles will improve traffic conditions
• Need for real scenario testing and evaluation

In addition, there are several other points concluded from users comments:
• Small number of users would prefer first come, first serve principle instead of priority.
• Participants suggested that there is a need for wider diversity of activities listed in trip purposes, since an activity can significantly influence PL selection.
• There were several cases when participant’s decision-making was primarily made from individual perspective, not necessarily taking into consideration other people in traffic. Consequently, there is a need for greater emphasize on cooperation and altruism when presenting PS.
• The arrival time window (i.e., how early or how late one should arrive) highly depend on the activity.
• Low ₡ number in combination with long estimated travel time and less important activity can influence people to change their departure time.
• Some users expect that other people should plan their daily activities well, and do not support the notion that lack of planning should validate for higher PL.

CONCLUSION

In order to evaluate proposed management framework, this research has implemented a revised Priority System into a web-based experiment. Web-based experiment was developed as a series of web pages, obtaining consent, providing information, and allowing the subject to interact with PS. Provided with hypothetical trip information and his own ₡, user was supposed to select PL per trip. Results from web-experiment show us that PL selection was altruistic and PL 4 was not selected often for trip purposes different from medical. Consequently, the frequency of PL selection is inverse to PL value, confirming the intended “loss aversion” feature of PS. However, one can notice inevitable randomness in human decision-making, potentially originating from different interpretation individuals have related to trip information or the operation of PS. Moreover, the results were influenced by the short-term interaction perspective that most users had. In addition, web-experiment has provided insights into PS operation, and users have provided a range of comments related to positive features, potential for failure, further development, factors in user decision-making, and points related to SDV technology in general.

At the end, it is important to emphasize several points. Since the introduction of internal combustion engine and microprocessor technology, transportation has not faced a potential technological impact of this scale. Self-driving vehicle technology is bound to revolutionize transportation, and probably our societies as well. In our research approach, we have tried to aim beyond resolving immediate negative effects, but to take into consideration the long-term impact on society that this technology might have. First, this is specifically related
to the notion of common humanity, through our cross-generation responsibility for sustainable development of technology. Moreover, the standpoint for technological development considers that technology is a socio-technical phenomenon. Consequently, decisions related to design of technology seize to be solely technical decisions, but they tend to have direct social implications. In addition, technology is connected with political decision, and can consequently manipulate reality and favor certain social classes [49].

Following this line of thoughts, we cannot lack the conscious reflections on the morals in technology, because it shapes the context of humans as moral agents and consequently it shapes humans themselves. This research endeavor was not planned to provide a final solution, but to be used as proof that such an endeavor is possible. The long-term vision for SDV and MaaS technology will need to achieve a careful balance between the needs of multiple segments of population in the current and future generations. This result will never be accomplished without a wider discussion, including not just engineers and entrepreneurs, but general public as well. One sure point that this research has shown is the capability of web-based experimentation for redevelopment of PS or development of other approaches for anthropocentric mobility technology. In addition, online environment has a potential for providing space for reflective vision and critical conversations that could provide essential understanding of the relevant values and their function in lives of people and groups. Finally, this research has shown that there is a need for greater understanding of human decision-making and planning in relation to the proposed framework, but also in relation to trip planning taking into consideration a range of features future mobility technology might have.
REFERENCES


What characterises a sustainable MaaS business model?

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Abstract

This paper examines the ways in which business models for MaaS can generate sustainable value, that is, value that extends beyond the traditional ‘profit norm’ embedded in business models, and belongs to the economic, environmental and social dimensions of sustainability. We draw on the growing literature on sustainable business models to explicate a set of principles and guidelines for generating sustainable value, and address one key function of a business model that is often overlooked in this field – value capture. We then identify different ways in which MaaS business models can generate sustainable value, linked to mobility services, data-based services, environmental technology and material recirculation. We identify potential mechanisms for value capture, and discuss the implications of our findings for practitioners and future research.

KEYWORDS Mobility services, business models, value capture, sustainable development

1. Introduction

Generally, business models are increasingly recognised as a vital component of transitions towards sustainability (Bocken et al., 2014; Bocken and Short, 2016; Boons and Lüdeke-Freund, 2013a; Schaltegger et al., 2016, 2012; Stubbs and Cocklin, 2008). For example, several works have noted that new business models may unlock the economic potential of electric vehicle technology and assist in its adoption (e.g. Budd Christensen et al., 2012; Costain et al., 2012; Weiller et al., 2015), but there exists no such work on Mobility as a Service (MaaS), although it can, in principal, revolutionise the way we travel and has a huge potential to improve the sustainability of the transport system. Whilst is not presently clear which business model/s will underpin the development and adoption of Mobility as a Service, it is possible to outline the characteristics of a sustainable MaaS business model. This paper aims to address the following research question:

“What characterises MaaS business models that deliver improvements in the economic, environmental and social sustainability dimensions?

In order to address this question, we must first tackle the sticky problem of understanding how to treat MaaS as a concept that currently lacks a formal and robust definition. MaaS is often described as an alternative to private vehicle ownership that combines different types of mobility services as part of a single, seamless offering made available to users via subscription-based smartphone applications (Beutel et al., 2014; Goldman and Gorham, 2006; Sochor et al., 2015), and is also referred to using the rubrics ‘combined’ or ‘integrated’ mobility services. However, the MaaS concept can refer to different types of services, and there are several ‘things’ that can be integrated within any MaaS initiative. Also, at the current, pre-commercial phase, it makes little sense to attempt to define MaaS as the field is in a state of fluidity, with several innovative concepts being tested. Hence any pre-emptive definition would run the risk of quickly becoming redundant, especially given the current level of hype around the MaaS concept. Instead, it is better to treat MaaS in
topological terms by classifying different elements in terms of what may be integrated in a single service (Table 1).

A business model is commonly referred to as a device for creating, delivering and capturing value (Chesbrough, 2010; Johnson et al., 2008; Osterwalder and Pigneur, 2010; Teece, 2010; Zott et al., 2011; Zott and Amit, 2010). Hence in order to examine what characterises sustainable MaaS business models, it is important to consider: 1) the concept of sustainable value; and 2) the ways in which MaaS, as a topological phenomenon, can be translated into a set of business models that create, deliver and capture sustainable value. These two points underpin the structure of this paper, which consists of four sections, of which this is the first. The next section outlines the methods deployed, focusing on an integrative literature review. Section three presents our main findings, outlining a set of principled arguments regarding sustainable MaaS business models, supported by practical examples. The last section concludes with a set of implications for practitioners and further research.

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<tr>
<th>Level of integration</th>
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<td>Integration of the service offer</td>
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<td>Integration of booking and payment</td>
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Table 1: Different levels of integration within MaaS and value generated. Source: Sochor et al. (2017).

2. Methodology

MaaS has been described as a concept that can deliver sustainability gains in terms of reduced congestion and transport emissions and improved accessibility. MaaS is also billed as an innovation opportunity, underpinned by the development of new business models in transport, such that it can deliver economic benefits. Until now, however, little has been done to examine how business model innovations in the MaaS field can generate sustainable value. To address this shortcoming, we performed an integrative literature review, which is defined as “a form of research that reviews, critiques, and synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated” (Torraco, 2005, p. 356). Here the topic in question is related to the way in which different MaaS business models can generate sustainable value. Given that this topic is not addressed by any single literature, we elected to focus on existing literatures on business models and the related subfield of sustainable business models, together with the more general literature on mobility services. In perusing these literatures, we sought to identify and synthesise a set of key ideas, concepts and principles that can be used to address our research question (What characterises MaaS business models that deliver improvements in the economic, environmental and social sustainability dimensions?). The overall aim was to deliver a fresh and consolidated perspective on how MaaS can generate sustainable value that is useful for MaaS practitioners when designing and further refining MaaS services, and a basis for further research on this topic.
3. Sustainable business models for MaaS

Many practitioners argue that MaaS comprises a user-centric approach, suggesting that creating user value is the main aim. However, MaaS can and should aim higher than this by contributing to the development of a more sustainable transport system. Generally, mobility services such as car sharing are recognised for their sustainability attributes, in terms of better urban management; improvements in energy efficiency and urban air quality; greater use of renewable fuels; reduced congestion and improved accessibility (Greenblatt and Saxena, 2015; Greenblatt and Shaheen, 2015; Rydén and Morin, 2005). The limited evidence available suggests that MaaS can bring about more sustainable forms of travel behaviour (Karlsson et al., 2017; Karlsson et al., 2016; König et al., 2016b; Sochor et al., 2016a, 2016b, 2015a, 2015b, 2015c, 2014; Strömberg et al., 2016). Taken together, these studies indicate that MaaS has the potential to generate sustainable value that benefits more than just individual users.

Considering the ways in which MaaS can generate different types of value brings us squarely to a discussion on business models. What types of value does MaaS generate? For whom? Which actor/s are able to capture and distribute different types of value? And what characterises MaaS business models that generate sustainable value? These issues are discussed in the following sections.

3.1. What is a business model?

Generally, a business model is regarded as a device for creating and capturing value, and for delivering that value to customers (Chesbrough, 2010; Johnson et al., 2008; Osterwalder and Pigneur, 2010; Teece, 2010; Zott et al., 2011; Zott and Amit, 2010). The concept of a business model is rather new and is thus not robustly defined. However, one oft-cited definition is provided by Teece, (2010, p.179):

“A business model describes the design or architecture of the value creation, delivery and capture mechanisms employed. The essence of a business model is that it crystallizes customer needs and ability to pay, defines the manner by which the business enterprise responds to and delivers value to customers, entices customers to pay for value, and converts those payments to profit through the proper design and operation of the various elements of the value chain”.

The above definition makes it clear that traditional conceptualisations of business models consider how value is created for and delivered to customers, and how value is captured by firms. Other conceptualisations share this idea. The Osterwalder (2004) ‘canvas’, for instance, can be used to categorise different business model types, and describes nine constituent ‘building blocks’. These include: a value proposition (i.e. a product or service that is offered to customers), a customer interface, supply chain relationships, a financial model (i.e. a cost and revenue structure that distributes benefits across business model stakeholders), partners, distribution channels and other key resources and processes (Osterwalder, 2004; see also: Bocken et al., 2014; Johnson et al., 2008; Zott et al., 2011b). A broader conceptualisation, which focuses on the “total value creation for all parties involved” (i.e. suppliers, partners and customers) is offered by Zott and Amit (2010, p. 218). The latter characterise business models as ‘activity systems’, describing content (what is done), structure (how it is done) and governance (who does it).

Both the activity system approach and the Osterwalder ontology can be used to explore the network of contracts and agreements within different MaaS services, in other words how value is created, delivered and captured via value chain collaborations. Uber, for instance, relies on privately-owned assets (vehicles) that are made accessible to users via multi-sided platforms. Uber captures the value generated via provisional
fees on each transaction made via the platform. By contrast, MaaS Global and UbiGo creates value via a set of contractual arrangements with different service providers and by repackaging and bundling these services into a single offer. This value is captured via a subscription-based payment model. Yet neither the Osterwalder ontology nor the activity systems approach consider the ways in which business models generate sustainable value, that is, value for stakeholders other than the end-users of a product or service. In order to examine the way in which MaaS can generate sustainable value, we turn to the field of sustainable business models.

3.2. What is a sustainable business model?

The development of new business models is increasingly linked to sustainability (Bocken et al., 2014; Bocken and Short, 2016; Boons and Lüdeke-Freund, 2013a; Schaltegger et al., 2016, 2012; Stubbs and Cocklin, 2008). As a consequence, a body of literature on sustainable business models (SBMs) has emerged in the past decade. Similar to the work on corporate social responsibility, much work in this field has taken issue with the ‘profit normative’ orientation of business (Upward and Jones, 2016). The latter is critiqued for measuring firm success in terms of economic performance, serving a narrow set of stakeholders (i.e. shareholders). By contrast, SBMs aim to broaden the definition of value creation by integrating social and environmental performance into the fabric of business. SBMs are thus defined in terms of their ability to internalise the three sustainability dimensions into the core of business:

“A business model for sustainability helps [in] describing, analyzing, managing, and communicating (i) a company’s sustainable value proposition to its customers, and all other stakeholders, (ii) how it creates and delivers this value, (iii) and how it captures economic value while maintaining or regenerating natural, social, and economic capital beyond its organizational boundaries” (Schaltegger et al., 2016, p.4).

And:

“…a sustainable business model is one which is both sufficiently profitable and that results in a process of comparative absolute or relative reductions in environmental and socioeconomic burdens through the delivery of socially relevant products and services. Sustainability is not an absolute end-point, but rather an improvement process whereby future generations are progressively less prejudiced by contemporary practices” (Wells, 2016, p.3)

These definitions are successful in acknowledging the negative social, economic and environmental externalities of business, and note that SBMs are those which either reduce existing burdens (make things less bad) or have positive impacts (make things good). SBMs can thus be viewed as a subgroup of normative business models, referring to the set of norms that become embedded in business models through a process of institutionalisation (Randles and Laasch, 2016). A narrow view of shareholders, as profit maximisers, is what lies behind the critique of (unsustainable) business models as ‘profit normative’, as noted above. Here sustainability can be regarded as one set of norms and values among many, such that business models are pitched as capable of resolving a variety of societal issues (Randles and Laasch, 2016).

Related to the topic of sustainability norms embedded within business models, scholars have outlined a set of principles upon which to base SBMs. These include things like: resource efficiency, social relevance, longevity, localisation and engagement, ethical sourcing and work enrichment (Wells, 2016); sustainable supply chain management, the management of production and consumption phases, the equitable distribution

1 Sometimes referred to as ‘Sustainability Business Models’ (e.g. Wells, 2016), or ‘Business Models for Sustainability’ (e.g. Abdelkafi and Täuscher, 2016).
of financial costs and revenues among involved stakeholders (Boons and Lüdeke-Freund, 2013); using a triple bottom line metric to assess performance, stakeholder engagement, environmental stewardship, and systems thinking (Stubbs and Cocklin, 2008; see also: Upward and Jones, 2016). This broad set of principles reflects the prescriptive tone taken within the SBM literature, which seeks to radically transform and reform societal structures and institutions in a broader process of transformation (Randles and Laasch, 2016).

One aspect that is overlooked in some studies from this field is that a business model is a mechanism for creating and capturing value. SBM scholars that do acknowledge the importance of value argue for a broad definition of it, as reflected in the following statement:

“…a business that contributes to sustainable development needs to create value to the whole range of stakeholders and the natural environment, beyond customers and shareholders” (Schaltegger et al., 2016, p.4).

Whilst the creation of social and environmental value is undoubtedly desirable from a sustainability perspective, the question of how firms can capture these types of value is largely left unanswered by the SBM literature. Traditionally, business models allow firms to directly capture value via sales of products or services, whose utility fulfils a customer need or want. Value capture is conducted through the market, where business models serve to assign prices to goods (products or services). Capturing value becomes much more complex when a market does not exist, rendering such goods uncommodifiable. This is arguably the case for many goods with social and environmental value, hence the economic terms ‘market failure’ and ‘externality’. Even in cases where public sector organisations create mechanisms to internalise externalities, such as subsidies for public transport, one can argue that a market exists. Hence public transport, which typically captures the social and environmental value inherent in its offering via ticket sales and subsidies, can be seen to have a financially viable business model. Where markets do not exist (e.g. creating social value for future generations) due to a lack of paying customers, designing financially viable SBMs becomes much more challenging.

The main challenge in capturing sustainable value is related to the concept of merit goods. A merit good is defined in terms of the private and public benefits inherent in its consumption, where the latter outweighs the former (Musgrave, 1957). In other words, the consumption of a merit good generates positive externalities (or less bad negative externalities) that are greater than private benefits perceived the individual consuming the good. An example may be the treatment of a contagious (yet not life-threatening) disease via medication, where the benefits of vaccination may be of greater benefit to the public than to the individual that is inoculated. The fact that the public benefit is greater than the private means that individuals under-consume merit goods in a free market, warranting state (or other third party) intervention. The importance of merit goods has been noted in studies on business models for shared mobility (Cohen and Kietzmann, 2014). Further, the public good aspect of public transport is what in many cases warrants support from the state coffers.

This reasoning can be used to understand the inability of firms in capturing sustainable value, due to the fact that the public benefits often outweigh those which are private. Hence we posit that for a MaaS business model to be sustainable, one cannot ignore the function of value capture. It is unlikely that any organisation (public or private) will aim to generate sustainable value if they cannot appropriate revenues directly or

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2 Public transport generates both social and environmental value, i.e. value for the collective, in terms of reduced emissions and congestion that would probably arise if it did not exist and travellers instead utilised private modes such as cars.
benefit via some other form of indirect returns (e.g. competitive advantage, market position, brands). How can firms capture such value?

There is evidence to show that environmental value can be captured indirectly. In a review of the literature on corporate environmentalism, Abdelkafi et al. (2013) argue that SBMs with environmental value propositions allow firms to enhance their brands; boost their image and reputation; attract and retain talented workers; improve resource efficiency; support higher sales volumes; reduce investment risks; attract financial capital; build trusting relationships with stakeholders; attract new customers; and promote customer loyalty. However, firms can experience difficulties in capturing environmental value, as in some cases environmentally-oriented firms demonstrate lower economic performance in comparison to firms that are not environmentally oriented (Linder et al., 2014).

There are some cases where environmental value can be captured directly as a result of paying customers that are willing to express their environmental concerns with their wallets, such as the growing market for premium electric vehicles (e.g. Tesla, Prius). However, the consumption of such goods is often also linked to individuals’ willingness to pay for products that confer a certain status or identity (e.g. the wealthy, environmentally conscious consumer). Firms can also capture the value of environmental value propositions directly by minimising waste (i.e. becoming more resource efficient), allowing for cost savings (Porter and van der Linde, 1995). Regardless of whether the value of an environmental value proposition is captured directly or indirectly, the ability to capture value is arguably dependent on the salience of environmental issues in the external business environment.

3.3. How can MaaS business models create, deliver and capture sustainable value?

In order to examine the potential for MaaS business models to generate sustainable outcomes, it is important to consider different types of MaaS services, the value they may generate, and ways in which that value may be captured. To reiterate, for a MaaS business model to be sustainable, one cannot ignore the function of value capture. Hence we now investigate ways in which MaaS business models can create, deliver and capture sustainable value.

Customer segments

Although MaaS currently lacks a robust definition, existing attempts to characterise the concept highlight some of its potential sustainability attributes. As noted in the introduction, Sochor et al. (2017) characterise MaaS in ‘topological’ terms, i.e. with reference to mobility-related services that exist at different levels of integration. Seen this way, MaaS comprises a set of different mobility-related services that can potentially generate different types of value, for private individuals and for broader publics. For example, there is evidence to suggest that a level 3 MaaS service, entailing the integration of different mobility services into a single offer: 1) is attractive to customers in terms of flexibility, convenience and cost; 2) may be a viable alternative to private car ownership; and 3) may encourage a shift towards more sustainable modes of travel such as public transport, walking and cycling (Karlsson et al., 2016; Sochor et al., 2016b, 2015b). Hence the value created by such services is delivered to:

1. Customers, who gain access to an attractive, cost effective and convenient mobility service;
2. The environment, via lower transport emissions);
3. Society, which benefits from lower congestion and improved accessibility.
Each type of value listed above can be captured by a level 3 MaaS operator via sales of the service to users. Note that the value captured by operators is redistributed to partners in the value chain. Partners must be alerted to the opportunities of collaborating in a MaaS ecosystem to overcome the tendency towards protectionism and risk aversion. That is, MaaS operators, acting as the focal organisations which capture the value generated by MaaS business models, must create an offer which allows partners (e.g. upstream transport service providers such as public transport operators and taxi firms) to expand their existing customer base. Further, MaaS operators must ensure that the value captured is distributed within the ecosystem in a manner that is just and legitimate among partners. Without this, transport service providers are unlikely to enter into partnerships as they will foresee risks of other actors cannibalising their offers, which is arguably the main reason public transport operators are currently unwilling to allow MaaS operators to resell the full range of available tickets. The upshot is that the viability of level 3 MaaS business models depends on their ability to attract customers from new market segments, namely those beyond their partners’ existing customer base. In practice, this refers to segments where customers either walk, cycle, or drive (or ride in) a privately-owned vehicle. For level 3 MaaS business models to be sustainable, however, they must also ensure shifts to more sustainable modes. The sum consequence is that the viability and sustainability of level 3 MaaS business models hinges entirely on their possibility to attract customers from the private car segment. Without this, the provision of low cost, convenient access to combined mobility services may result in shifts to modes which are less environmentally sustainable (e.g. travellers from the public transport segment may increasingly travel by car).

Similar arguments can be made for level 0 MaaS services such as station-based and free-floating car sharing initiatives. If the provision of these services does not attract users from the private car segment, then these services will likely not result in environmental sustainability improvements. However, car sharing can improve accessibility, which belongs to the social sustainability dimension. That is, users can gain access to a flexible alternative to taxis/public transport that grants better accessibility in towns and cities. Hence car sharing represents a potential trade-off between environmental sustainability and accessibility (note that this also applies to car sharing in level 3 MaaS). The trade-off between environmental sustainability and accessibility further accentuates the need for MaaS service providers to target existing and potential private car owners. Without this, the consumption of MaaS services will not result in the reduction of environmental burdens, and level 3 MaaS business models will not be feasible in the eyes of value chain actors. In other words, without targeting private car owners, the consumption of MaaS services will not generate sustainable value.

Travel behaviour

As noted above, while some scholars have noted that car sharing may facilitate shifts to more environmentally sustainable transport modes (e.g. Firnkorn and Müller, 2011), others have voiced concerns that modal competition may result in a shift in the opposite direction (e.g. from public transport to car sharing) (Stillwater et al., 2009). In reality, MaaS will likely facilitate modal shifts in both directions, that is, some users will shift from less-to-more environmentally sustainable modes, and others will move in the opposite direction to fulfil their accessibility needs. Hence in addition to attracting users that are currently within the private car segment, it is important that MaaS operators encourage sustainable travel behaviour by creating incentives for the utilisation of more environmentally sustainable modes and for ride sharing. In practice MaaS operators must find innovative ways to improve accessibility and promote environmentally sustainable travel behaviour, particularly in geographical contexts where public transport is sparser (e.g. rural areas). The simplest way
to create incentives is through pricing, such that more sustainable modes and ride sharing are made cheaper than less sustainable alternatives. In terms of environmental sustainability, the least pollutive mode within a level 3 MaaS service is walking, followed by cycling, public transport, car sharing and finally taxi. Pricing these modes in terms of their environmental impacts is not necessarily a challenge, as more pollutive modes are generally more expensive.

It may appear to be difficult for MaaS operators to capture the value of modes such as walking and private cycling, since they are not commodified within the business model (i.e. users do not pay to walk or use their own bicycles). However, it may be possible to increase savings if users elect to walk or cycle rather than utilise a mode that would entail a cost to MaaS operators (public transport, taxi, etc.). Similar arguments could be made for ride sharing and non-travel options such as virtual meetings. In practice, the opportunities to capture this type of value relate to the composition of payment models. Pay-as-you-go models disallow value capture, as users will only pay for their actual use, creating no incentives for MaaS operators to minimise costs. This is not the case for subscription packages, assuming users pay a lump sum for a predetermined travel allowance, and if rebates or deferrals are not provided for unused credits. In such circumstances, MaaS operators would be able to capture the value of walking and cycling in the form of cost savings. However, this type of payment model may have rebound effects if users rush to use up their credits prior to the start of a new subscription period (likely a new month). Notwithstanding, it does appear to be possible for level 3 MaaS operators to capture the value inherent in incentivising sustainable modal shifts. Aside from (or alongside) pricing, MaaS operators can create other types of incentives, through mechanisms such as nudging and gameification, that encourage sustainable travel behaviour. These types of mechanisms can be directly integrated into MaaS software applications, and value can be captured in the same manner described above.

**Data-based services**

One way in which to better understand modal choice in MaaS-based transport systems is to leverage the power of big data analytics. Willing et al. (2017) review the literature on multimodal platforms (MMPs), which refer to a range of information services that allow travellers: to compare different transport options; to make informed selections according to preferences (usually trip duration and cost); and to plan and re-plan trips en route (see also: Motta et al., 2015). Some MMPs also facilitate bookings and payments (cf. levels 1 and 2 in the Sochor et al. (2017) topology). Most MMPs provide informational services for free, and collect user data which is typically anonymised and aggregated before being put to use.

Aside from individual travellers, data analytics can be used to create value for different stakeholders in the MaaS ecosystem, including transport service providers and government or regulatory bodies. Transport service providers, for instance, can gain real-time data on customer demand, which can help to deal with tasks such as the relocation of shared cars in free-floating systems; to optimise service coverage according to geographical and temporal variations in demand; and to understand revealed user preferences regarding modal choices as a means to improve the service offer (Willing et al., 2017). This type of data is also of interest to governmental bodies such as city planners and municipalities, who are charged with the responsibility of minimising congestion and governing infrastructures such as roads and parking (Motta et al., 2015; Willing et al., 2017). Arguably, the value of big data analytics has network effects – as more data is generated the value becomes greater in terms of private and public benefits. Hence as (or if) MaaS services proliferate, the sustainable value that data analytics generates will increase. The value of data analytics is likely created by MaaS integrators, a role in the ecosystem which refers to ICT platform providers (i.e. actors that provide
access to and operate multimodal platforms) (Smith et al., 2017). The value can be captured, in principal at least, via sales or agreements with stakeholders such as transport service providers, MaaS operators, city planners, municipalities, and transport authorities. Integrators may also capture value via advertising revenues in a similar way as actors such as Google generate revenue streams, or via provisional fees for individual transactions (e.g. ticket sales).

Resource efficiency

Changes in travel behaviour in the form of modal shifts and ride sharing can reduce the environmental impacts of the transport system. These types of actions improve the resource efficiency of the transport system by reducing the number of material inputs (e.g. vehicles, road infrastructure) required to fulfil user needs. The resource efficiency of the transport system also depends on the technologies deployed within vehicles and is critical to the decarbonisation of the transport system. This can be realised by introducing environment friendly technologies such as electric vehicles into MaaS fleets. Autonomous vehicles may also have a role to play in reducing transport emissions (Greenblatt and Saxena, 2015; Greenblatt and Shaheen, 2015). Can MaaS business models generate sustainable value via the deployment of environment friendly vehicle technologies?

Generally, it is widely understood that there is a link between business models and technology. Although the two are distinctly separate concepts (Baden-Fuller and Mangematin, 2013), business models are mediating devices that capture the value of technology and deliver it to customers (e.g. Chesbrough, 2010; Chesbrough and Rosenbloom, 2002). That is, without a functioning business model, new technologies are merely inventions in need of commercialisation. A new technology is seen as useless without a complementary business model: “the inherent value of a technology is latent until it is commercialized” (Björkdahl, 2009, p. 1470). The often cited case to highlight this point is that of Xerox Corporation, whereby a new, technologically superior photocopier was developed but could not be commercialised without a radically new business model (Chesbrough and Rosenbloom, 2002). In line with this thinking, several scholars have noted that new business models can unlock the potential of electric vehicle technology and assist in its adoption (e.g. Weiller et al., 2015; Budde Christensen et al., 2012; Costain et al., 2012).

It may be possible for MaaS business models to capture the sustainable value inherent in technologies such as electric and autonomous vehicles, resulting in a more environmentally friendly, sustainable transport system. If vehicles (particularly cars) are utilised more frequently as a result of being utilised within a MaaS service, then their operational costs take a more accentuated role in determining the types of technologies deployed. In cases where market competition exists between different MaaS operators, fleet owners will be forced to compete on cost. This has two principal implications for the environmental sustainability of the vehicle fleet. The first is in the vehicles’ use phase, where incentives will exist for fleet owners to deploy vehicles with low running costs. If electric vehicles have lower running costs than fossil fuel vehicles, then fleet owners will, in principal at least, be able to capture the sustainable value inherent in electric vehicle technology in the form of cost savings. In practice, the deployment of electric vehicles depends on other factors, such as the costs of installing recharging infrastructure and the range of electric vehicles, which influences their availability. Notwithstanding, the fact that electricity is generally a lower cost fuel than petrol and diesel means that value capture may be possible. Similarly, if it can be shown that autonomous vehicles lower costs for fleet owners, then a viable business case can be put forward. In both cases, value may be captured by both fleet owners and MaaS operators, assuming the two are different actors. In addition, MaaS operators may be able
to capture the value of this type of environmental offering through indirect channels, as described in section 3.2. Further, higher utilisation rates mean that the vehicles in a MaaS system will be renewed more frequently than privately-owned vehicles, allowing for more rapid technological substitution.

In cases where it is not possible to capture value directly via cost savings, it may be possible to collect revenues via public policies that create incentives for the deployment of environmentally friendly vehicle technologies. Given their climatic benefits, several governments have created subsidies and tax exemptions for electric vehicles, for instance, and decarbonisation is increasingly enshrined as a transport policy goal. Hence in the future one may reasonable assume that governments will increasingly support environment friendly vehicle technologies via supportive and/or punitive measures (i.e. those which make the consumption of fossil fuels more expensive, such as carbon taxes).

The second implication is that cost competition between MaaS operators may result in attempts to find cost savings further upstream in the value chain. One way to achieve these types of cost savings is to prolong product (i.e. vehicle) lifespans by recirculating physical materials, akin to the principles of a circular economy. This is especially pertinent given that vehicles in a MaaS system will be utilised more than privately-owned vehicles, and thus wear out more rapidly. In a circular economy, material can be recirculated via different cycles, such as reuse, remanufacturing and recycling. Remanufacturing, for example, has been shown to simultaneously generate environmental benefits and cost savings by minimising waste in manufacturing processes (e.g. Amaya et al., 2010; Guide, 1997; Ijomah, 2009; Lindahl et al., 2006; Smith and Keoleian, 2008). The main reason that MaaS creates incentives for material recirculation is because of the development of product-service business models (i.e. those which give access to products as services), which have been cited as an key enabler of a transition to a circular economy (Linder and Williander, 2015; Tukker, 2015). Similar to the deployment of environment friendly technologies, the value of material recirculation can be captured through cost savings. However, the question of which actor captures this type of value is unclear, as new value chains are required to facilitate material recirculation (Ferguson, 2010). Hence gains in resource efficiency in the form of environmental technology and material recirculation are future-oriented business model activities that require new forms of cross-industry collaboration (Sarasini et al., 2016).

4. Discussion

This paper sought to examine the issue of what characterises MaaS business models that deliver improvements in the economic, environmental and social sustainability dimensions. To address this question, we examined the concept of a business model, noting that it is broadly understood to be a mechanism for creating, delivering and capturing value. The concept of a sustainable business model extends the definition of value to encompass benefits in each of the economic, environmental and sustainability dimensions. Based on this understanding, we then sought to identify ways in which MaaS business models can create and capture sustainable value, noting that value capture is a fundamental element of business modelling that is often overlooked in the SBM literature. We identified three types of sustainable value that MaaS business models can generate, and outlined potential mechanisms for capturing this value. Our findings are summarised in Table 2.
### Potential ways in which MaaS business models can create and capture sustainable value.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Private value</th>
<th>Public value</th>
<th>Potential mechanisms for value capture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility services</td>
<td>Affordability, flexibility and convenience</td>
<td>Reduced congestion and emissions following sustainable modal shifts</td>
<td>Bundled mobility services, available to individual customers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improved accessibility</td>
<td></td>
</tr>
<tr>
<td>Data-based services</td>
<td>Trip planning, booking and payment</td>
<td>Real-time traffic management</td>
<td>Sales of data analytics to MaaS operators, transport service providers and public sector organisations</td>
</tr>
<tr>
<td></td>
<td>Mobility service optimisation</td>
<td>Urban planning</td>
<td>Provisional/brokerage fees for individual transactions</td>
</tr>
<tr>
<td></td>
<td>Travel time savings and lower mobility costs</td>
<td></td>
<td>Advertising</td>
</tr>
<tr>
<td>Resource efficiency I:</td>
<td>Lower mobility costs</td>
<td>Reduced congestion and emissions in vehicles’ use phase</td>
<td>Cost savings due to lower operational costs</td>
</tr>
<tr>
<td>Environment friendly vehicle technologies</td>
<td></td>
<td>Reduced environmental impacts in vehicles’ production phase</td>
<td>Cost savings due to lower cost of vehicle production</td>
</tr>
<tr>
<td>Resource efficiency II:</td>
<td>Lower mobility costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material recirculation</td>
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<td></td>
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</tbody>
</table>

**Table 2:** Potential ways in which MaaS business models can create and capture sustainable value.

### 4.1. Implications for MaaS practitioners

Our findings have some practical implications. One major implication is that for MaaS business models to be truly sustainable, MaaS operators must consider the different elements of sustainable value when designing new business models and when refining existing ones. In many instances, generating sustainable value is linked to details within the business model, such as targeted customer segments, the pricing of different transport modes, and the way in which different payment models influence travel behaviour. A more nuanced understanding of these factors and the way in which they influence sustainable outcomes is needed as a basis for MaaS business modelling. Also, our findings sought to outline a set of future oriented opportunities for sustainable value generation via resource efficiency gains. Realising these potentials in practice means that practitioners from different sectors must establish new forms of collaboration to facilitate the deployment of environment friendly vehicle technologies and material recirculation. These are intended more as medium- to long-term aims rather than immediate objectives. In the short term, practitioners should focus on developing business models that generate sustainable value by 1) identifying the different ways in which MaaS business models can create different types of sustainable value; 2) finding ways to capture that value, either directly in the form of revenues or indirectly in the form of other types of economic benefit; and 3) understanding potential trade-offs between, for instance, environmental sustainability and accessibility. We contend that a more nuanced understanding of how business models can generate sustainable value will not only benefit the sustainability of the transport system – it will also allow practitioners to act as advocates of MaaS in broader settings, creating legitimacy for the concept and serving to create a set of enabling conditions to allow it to flourish.
4.2. Implications for future research

The three types of sustainable value outlined in this paper are linked to the mobility and data service elements of MaaS business models, and the resource efficiency of the transport system. This is not an exhaustive list, but an initial set that may be expanded on in future studies. Further, we focused on the ways in which MaaS business models can create and capture sustainable value, obscuring other elements of business models that may potentially influence sustainability outcomes. One such function of a business model is its scalability, which can be defined as the capacity or potential for a particular business model to expand effectively and efficiently by reaching larger numbers of customers and new markets (Jolly et al., 2012). Scalability is central to the ‘innovativeness’ of MaaS business models, and may thus fall under the economic sustainability dimension. Examining scalability as a potential enabler of sustainable value delivery is an interesting way of building on this study, and may be used to compare different types of MaaS business models, according to the roles taken by private and public actors in the business ecosystem (e.g. König et al., 2016a). Finally, while the literature provides some useful guidance in terms of principles that should be embedded in sustainable business models, a more nuanced set of tailored guidelines is needed for developing and assessing the sustainability of MaaS.

5. References


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SCIENTIFIC 4

Market potentials
Users’ motives to adopt and willingness to pay for Mobility as a Service

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Purpose

Mobility as a Service (MaaS) is a new concept that could revolutionise the way we travel. However, a robust understanding of users’ willingness to adopt MaaS services; preferences among different transport modes; and willingness to pay for MaaS is currently limited by the small number of pilots and field operational tests in real-world settings.

Achieving behavioural change is a complex task. Mobility is a part of people’s everyday lives – not just an activity on its own – but rather a connector between other activities (Banister, 2008). The flexibility that personal car ownership affords is just one of several factors that entrench the current automobility regime and make it difficult to reorient the transport system (Geels, 2002). Yet the provision of MaaS can positively affect people’s possibilities and willingness to engage in various activities and thus improve accessibility (Farrington and Farrington, 2005). So-called millennials are less likely to purchase automobiles, and travellers are increasingly motivated by health and environmental concerns. However, a so called ‘attitude-behaviour gap’ exists among travellers, such that environmentally positive attitudes are not always manifested in environmentally positive behaviour (Bamberg et al., 2011; Lane and Potter, 2007; Møller and Thøgersen, 2008; Peters et al., 2015; Pooley et al., 2013). Underlying reasons include conflicting goals between sustainability and other everyday activities, alongside demands for satisfaction, comfort, speed, as well as passengers and luggage (Anable and Gatersleben, 2005).

This study aims to improve our understanding of user perspectives by addressing the following research question:

“What motivates users’ to adopt MaaS services and what is their willingness to pay?”

Methodology

This study utilises user surveys that focus on individuals/families that have participated in pilots and field operational tests of MaaS in Sweden and Finland. We conduct analyses of 2-4 case studies, including UbiGo (SE), Tuup (FI) and Ylläs Around (FI) as part of a wider project entitled BoMaaS (Building the Open MaaS Ecosystem), funded by Tekes.

Findings

Our findings elucidate a range of factors that influence users’ inclination to adopt MaaS as a replacement or supplement to private car ownership. These include: the combination of modes within MaaS offerings; the convenience and usability of the service; the design and function of smartphone applications; environmental motivations; and so on. Our study also explores users’ expectations before and after having trialled a service, investigating whether these expectations have been met. We also explore users’ willingness to pay for MaaS offerings by investigating their perceptions of the pricing models in existing MaaS services.
Implications

We generate knowledge that can directly influence the development and implementation of sustainable MaaS services. The study derives implications for practitioners including MaaS operators and mobility service providers that are responsible for the delivery of MaaS. Further, our findings may be useful to stakeholders that have an interest in understanding the social implications of MaaS in different settings. Such stakeholders include public transport agencies and authorities, local governments and town planning offices.
What are the prospects for switching out of conventional transport services to mobility as a service (MaaS) packages?

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Mobility as a Service (MaaS), which develops plans that brings all modes of travel into a single mobility package, has received great attention from interested parties, including transport authorities, transport providers (public transport, car-sharing, bike-sharing, taxi, car rental), software developers, brokers, engineers, academics and environmental groups. Different business models have emerged in which it is planned for interested parties work together to provide integrated mobility services to MaaS subscribers, who in turn pay a subscription fee for the use of mobility services packaged into the MaaS plan. With such a smorgasbord of potential offerings, it is necessary to understand how large the market of MaaS would be if travellers are offered this one-stop access to a range of mobility services, and how much potential users might value each item included in a MaaS plan.

With a mobility plan customised to each subscriber, MaaS has a real potential to shift the traditional car ownership paradigm away from outright ownership, thereby changing the overall modal share given that car use starts from car ownership (Ho & Mulley, 2015; Maat & Timmermans, 2007). A shift in ownership is already being observed, accelerated by a myriad of mobility options such as Uber, GoGet (car sharing), CarNextDoor (peer to peer car sharing), bike-sharing, and ride-sharing schemes. A move from car ownership to shared membership will no doubt be affected by the increasing deployment of self-driving vehicles promoted by several major automakers and technology giants moving to make self-driving vehicles commercially available by 2020 (Muoio, 2016). The commercial release of fully self-driving vehicles opens new markets for car-sharing (as existing non-drivers will be able to travel in a fully self-driving vehicle on their own), suggesting the effect of car-sharing on car ownership will be substantial. Recent research evidence suggests that the mobility services offered by Uber and GoGet have resulted in deferring their users’ decision to purchase a car (Newberg, 2015; SGS Economics & Planning, 2012). This is a sign that shared self-driving vehicles and MaaS could deepen the reduction of private vehicle ownership, especially among the younger generations (Delbosc & Currie, 2013; Goodwin & Van Dender, 2013) since mobility will increasingly be achieved without the need to own a car or even a valid driving licence.

The impact of shared mobility on our cities and our lives is manifold and the question of how transport technology innovations might disrupt or alter urban transport systems and, in turn travel behaviour, is being highly debated with much speculation but little substantive insight. This is partly due to the lack of relevant behavioural data and models that can provide guidance on the potential uptake of new mobility opportunities and how emerging transport options will change travel choices in the short and long terms. This paper aims to set a benchmark in identifying mobility service packages that align with the preferences of travellers, how they may take these services up, and how drivers may question the necessity to own vehicles if and when offered one-stop access to a range of transport mobility options. This study is timely in informing MaaS providers as to the business model to follow and how best to package, cost and market mobility plans to end users to obtain sustainable goals by way of designing MaaS plans that are likely to have a high take-up rate.

Much of the existing literature has assumed that the key innovations behind MaaS in integrating public, intermediate and private modes, and linking customer information with fare integration sold as subscriptions
are sufficiently attractive enough in their own right for consumers. Whilst this may well hold true, it is important to investigate empirically the prospects for people to switch out of conventional transport services to MaaS packages. This study aims, using an on-line panel of respondents, to shed some light on a number of key unknowns around:

- What commercially-viable mobility plans can be created and marketed to transport customers?
- How large is the market for MaaS if a mobility broker (like MaaS Australia) offers its customers one-stop access to a range of travel services through a smartphone-based application?
- How large must travel cost savings be for consumers to take up MaaS plans and what are the implications for car ownership (including consideration of households disposing their second car)?
- How much would people be willing to pay for each mobility offering (hours/kms of car-sharing, days of unlimited public transport use, or kms of taxi/Uber)?
- How might mobility service subscribers alter their mix of travel between public, intermediate, private and active modes of transport and in what form will this take (e.g. first/last mile vs. point-to-point)?

The study highlights some important questions for policy-makers in the PT arena. The MaaS plans were not particularly attractive to existing PT users. To move towards the sustainable future craved almost universally by Governments all over the world, building PT patronage with choice riders is essential. This study suggests that there may be a need for lowering public transport fares, especially the daily and weekly cap, to attract more choice riders and to retain the current travellers. This does not necessarily mean that a greater subsidy is required since disruptive transport technologies could make the provision of public transport cheaper (through reducing operation costs or offering individual plans that take into account subscriber’s travel patterns including number of trips made and fare bands).

Another feature of this research that we have shown to be increasingly important in other studies unrelated to MaaS is experience with the alternatives (Hensher and Ho 2016). While MaaS in its full definition is not yet available in Australia (and indeed in most geographical jurisdictions), various modal elements are clearly well established (e.g., conventional public transport) or entering fast into various markets (e.g., Uber taxi based services and car sharing). The findings in this study reinforce the importance of accounting for experiences in use or awareness of specific modal inputs into MaaS packages, conditioning the utility expressions defining the attributes of each MaaS and Pay-as-you-go alternatives. This is particularly important in a preference model that will be updated over time on a regular basis as people get exposed to these new opportunities which will modify experience and hence can be expected to have a significant impact of preferences towards MaaS. What may be a meaningful preference regime today may very likely be unreliable in the near and far future as more and more MaaS plans are rolled out. Ongoing research must involve regular surveys in order to capture this changing experience setting, guiding ongoing assessment of the changing demand for MaaS plans and how it might impact on the future demand for choosing to use and pay for a single mode outside of a MaaS plan.
Review on Mobility as a Service in scientific literature

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Abstract

Our current private car based transport system is inefficient and unsustainable. The Mobility as a Service (MaaS) model is offering a solution by combining public and private transport modes and aiming to provide seamless trips over one interface. This study summarises the current state of the art of MaaS research by analysing scientific research papers. Overall, 16 MaaS-related documents in Scopus and ScienceDirect databases were recognised as relevant for this study. The relevant literature was divided into three groups according to the topics of the studies. The most significant observations are presented based on the literature and future research needs are discussed. Currently, there are relatively few MaaS-related scientific studies published, but the issue is topical as most of the relevant studies were published in 2016 or 2017. This study helps the MaaS stakeholders and the scientific community to recognize the current state of the art and where to focus in future.

1. Introduction

Increasing traffic volumes in cities because of urbanization, the need to decrease greenhouse gas emissions and constantly varying mobility needs call for new solutions for daily transport (El Zarwi et al., 2017). Sustainable transport should be in the centre of the solutions instead of current inefficient transport system, which is based on private cars with underutilized capacity (Strömberg et al., 2016). Everyday traveling from place to another should be possible by integrating flexible mobility options based on current needs. Competitive choices for private cars are called for. The transport system could be seen offering mobility services such in Mobility as a Service (MaaS) paradigm (Melis et al., 2016). In this new paradigm, user's needs are placed in the centre of the transport system.

Hietanen (2014) and MaaS Global (2017) state that Mobility as a Service concept aims to combine different transport modes (e.g. public transport, car-sharing, ride-sharing, taxis and bicycles) to seamless trips over one interface. A MaaS platform covers all necessary mobility operators that are needed to provide flexible and customized transport to different kinds of users (Kamargianni et al., 2016). The main idea is to fulfil mobility needs without need to own a private car or a travel card for public transport (Ambrosino et al., 2016; Giesecke et al., 2016). It is not novel that a journey to the destination can be made by combining different transport modes (e.g. public transport and car-sharing), but according to the new paradigm the whole package can be booked and paid with a mobile application (Hensher, 2017). A service portal forms the wanted trip chain on behalf of a customer and enables the whole trip via single payment or mobility package (Hietanen, 2014; Kamargianni et al., 2016).

The role of cars could change significantly in the new paradigm (Hensher, 2017). When the whole spectrum of mobility options is available via integrated service system, there is a great potential to individual mobility without owning a car. Combined use of public and private transport not only enables smooth mobility options but also provides alternatives for travelling (Melis et al., 2016; Melis et al., 2017). Decreased level of owning a private car is seen lead to increased use of alternative transport modes, hence raising the popularity of shared
mobility services and directing mobility to a more sustainable direction (Giesecke et al., 2016; Karlsson et al., 2016).

In order to provide integrated services, which enhance daily mobility options, real-time data of supply and demand is needed (Melis et al., 2017). Workable mobility services are complex systems as they gather information (e.g. timetables, real-time traffic data, car-sharing availabilities etc.) from various sources (Hilgert et al., 2016). Furthermore, the service platform needs to include all the transport operators in the system. Finally, applicable use of data enables MaaS to combine transport of passengers and goods to the same vehicle (Giesecke et al., 2016).

Disabled passengers’ difficulties to use a private car or public transport can be defeated in this new service concept (Atasoy et al., 2015). Particularly ride-sharing and taxi services can be more affordable as a part of the system, which provides better opportunities to individual mobility for disabled people. Generally speaking, conventional public transport cannot provide as good service level as a combination of other transport modes because public transport has fixed schedules and routes (Atasoy et al., 2015). MaaS can make it possible to reach the destination at a better service level (e.g. comfort and travel time), with a more expensive price or at the best possible price, if the service level is not the priority (Melis et al., 2016). Furthermore, customer’s need to carry any kind of goods is also considered (Giesecke et al., 2016).

As MaaS is a new paradigm in the transport system, an analysis of MaaS studies is needed to show what the interests and results in the research have been so far. This paper aims to summarise, what is MaaS concept about and what are the key issues in scientific literature on MaaS. The paper answers the questions:

- What has been scientifically published on MaaS so far, by whom, where and when?
- What is the role of different transport modes and services in MaaS?
- What are the key findings and experiences in MaaS pilots and trials?
- What are the effects of MaaS services?

The study is conducted by analysing the articles found in Science Direct and Scopus databases on Mobility as a Service. Reviewing the scientific literature helps the MaaS stakeholders and the scientific community recognize the current state of the art.

The paper is structured as follows: In section 2, research framework and included literature are described. Thereafter three different research issues are discussed and presented in an own section (sections 3, 4, and 5). Finally, section 6 discusses and concludes the main findings.
2. Materials and methods

Analysis in this paper is based on a literature study of peer reviewed scientific articles and conference papers. The search for relevant articles and papers was made in Scopus\(^1\) and ScienceDirect\(^2\) databases in June 2017. In Scopus 37 documents of which 13 were articles and in ScienceDirect 33 of which 22 were articles were found including the expression “Mobility as a Service”. Six documents were found in both databases. 16 of the 64 (37 + 33, of which 6 were the same) documents actually were fully MaaS-related. The non-related documents including the statement “Mobility as a Service” discussed for instance mobile networks or MaaS was only a minor part in the study (e.g. only one paragraph included MaaS considerations).

Based on the topics and issues discussed in the articles, the 16 articles were divided into three groups, which are partly overlapping each other. Following the research questions the groups are 1) the roles of different transport modes and services in MaaS, 2) the experiences of MaaS pilots and trials, and 3) the effects of new services. Furthermore, some articles introduce architecture and mathematics behind a mobility application or a scheme, but as this study focuses especially on mobility and transport system issues, these are not analysed in this paper. Many studies discuss a specific transport mode or some modes as a part of the MaaS scheme and thus the first group is justified and needed. The last two groups are somewhat similar. The greatest difference is that the second group describes results of smaller scale MaaS trials and describes some trials whereas the third group discusses the larger impacts MaaS has to the transport system based on enlightened assessments and common observations from trials. It is important to recognise that wide and comprehensive MaaS schemes do not exist yet. The 16 articles and conference papers, in which “Mobility as a Service” was mentioned and MaaS was widely discussed, are presented in table 1 with their main affiliation to the aforementioned groups.

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Table 1. The scientific articles and conferences papers found in Scopus and ScienceDirect in June 2017 with the expression “mobility as a service” and a major MaaS-relevancy. Article group refers to the grouping done for the analysis where 1 = the roles of different transport modes and services in MaaS, 2 = the experiences of MaaS pilots and trials, and 3 = the effects of new services.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Name of publication</th>
<th>County of main author’s institute</th>
<th>Publication type</th>
<th>Year of publication</th>
<th>Article group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambrosino et al.</td>
<td>Enabling intermodal urban transport through complementary services: From flexible mobility services to the shared use mobility agency: Workshop 4. Developing inter-modal transport systems</td>
<td>Italy</td>
<td>Article</td>
<td>2016</td>
<td>3</td>
</tr>
<tr>
<td>Brendel &amp; Mandrella</td>
<td>Information systems in the context of sustainable mobility services: A literature review and directions for future research</td>
<td>Germany</td>
<td>Conference paper</td>
<td>2016</td>
<td>3</td>
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<tr>
<td>Frei et al.</td>
<td>Flexing service schedules: Assessing the potential for demand-adaptive hybrid transit via a stated preference approach</td>
<td>United States</td>
<td>Article</td>
<td>2017</td>
<td>1</td>
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<tr>
<td>Gieseceke et al.</td>
<td>Conceptualising mobility as a service</td>
<td>Finland</td>
<td>Conference paper</td>
<td>2016</td>
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<tr>
<td>Heikkilä</td>
<td>Reorganization of the mobility service provision - Public governance as a contributor</td>
<td>Finland</td>
<td>Conference paper</td>
<td>2014</td>
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<td>Hensher</td>
<td>Future bus transport contracts under a mobility as a service (MaaS) regime in the digital age: Are they likely to change?</td>
<td>Australia</td>
<td>Article</td>
<td>2017</td>
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<td>Kamargianni et al.</td>
<td>A critical review of new mobility services for urban transport</td>
<td>UK</td>
<td>Conference paper</td>
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<tr>
<td>Kamau et al.</td>
<td>Demand responsive mobility as a service</td>
<td>Japan</td>
<td>Conference paper</td>
<td>2017</td>
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<td>Karlsson et al.</td>
<td>Developing the ‘service’ in mobility as a service: Experiences from a field trial of an innovative travel brokerage.</td>
<td>Sweden</td>
<td>Conference paper</td>
<td>2016</td>
<td>2</td>
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<tr>
<td>Lamotte et al.</td>
<td>On the use of reservation-based autonomous vehicles for demand management</td>
<td>Switzerland</td>
<td>Article</td>
<td>2017</td>
<td>2</td>
</tr>
<tr>
<td>Melis et al.</td>
<td>Public transportation, iot, trust and urban habits</td>
<td>Italy</td>
<td>Conference paper</td>
<td>2016</td>
<td>3</td>
</tr>
<tr>
<td>Melis et al.</td>
<td>Integrating personalized and accessible itineraries in MaaS ecosystems through microservices</td>
<td>Italy</td>
<td>Article in press</td>
<td>2017</td>
<td>2</td>
</tr>
<tr>
<td>Pakush et al.</td>
<td>Using, sharing, and owning smart cars: A future scenario analysis taking general socio-technical trends into account</td>
<td>Germany</td>
<td>Conference paper</td>
<td>2016</td>
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<tr>
<td>Rantasila</td>
<td>The impact of mobility as a service concept to land use in Finnish context</td>
<td>Finland</td>
<td>Conference paper</td>
<td>2016</td>
<td>3</td>
</tr>
<tr>
<td>Strömberg et al.</td>
<td>Trying on change - Trialability as a change moderator for sustainable travel behaviour</td>
<td>Sweden</td>
<td>Article</td>
<td>2016</td>
<td>2</td>
</tr>
<tr>
<td>Thai et al.</td>
<td>Resiliency of mobility-as-a-service systems to denial-of-service attacks</td>
<td>United States</td>
<td>Article</td>
<td>2016</td>
<td>3</td>
</tr>
</tbody>
</table>

The bibliometrics of the 16 publications (presented in Table 1) of which seven are scientific articles (one of them article in press) and nine conference papers were analysed. All of the scientific articles have been published in different journals and hence there is not any specific journal that is more popular than others. As the number of articles is low and they are published in various journals, any specific journal cannot be recognised publishing certain kind of MaaS-studies e.g. according groups used in this paper.

It can be clearly observed that Mobility as a Service is a new approach in scientific literature as 15 of 16 documents have been published in 2016 or 2017. The earliest article recognized for this paper but is not included in the table 1 is Huwer’s (2004) study, which did not use MaaS as a term but discussed the role
of car-sharing and public transport and effects of their combination. Atasoy et al. (2015) published one of the first scientific MaaS articles although it does not include the term “Mobility as a Service”. The article presents a MaaS-trial, which is discussed at a conceptual level in the article. Before that, Heikkilä (2014) introduced a MaaS concept for the City of Helsinki in her master thesis. Especially thereafter, Finland has had a strong ambition to promote Mobility as a Service.

Most of the scientific articles and conference paper writers have been authors only in one of the publications, which make the author base of MaaS publications broad when considering the number of publications. Only Melis (Melis et al. 2016, 2017) has been the first writer in two articles or conference papers. Furthermore, six writers have been either as a first author or a co-writer in two studies. Analysis on the first writer’s organization reveal that MaaS studies are mainly reported by universities. In four publications the main writer’s organization is consultant firm, a research centre or municipality. Based on the nationality of first writer’s organisation, MaaS seems to have a strong basis in Europe (12 publications) and particularly in Finland and Italy, both with three publications. In two publications the main author’s organization is from the USA. Overall, the first writers represent organisations in the developed countries.

Seven of the publications included in this study describe mainly the effects of new services (group 3). Six studies were placed to group 2 and the rest three studies to group 1. Division to the specific groups was made according the main topics of the publications. However, some of the studies include more than one angle to MaaS and thus they could be placed to another group beside of the main group. As a result of low number of publications, valid conclusions about the most popular topics cannot be done, and as new publications are expected, the situation regarding the grouping is expected to evolve.

As many studies have addressed issues similar to MaaS without the term “mobility as a service” in the document, yet these relate to MaaS, other MaaS-related articles were included in the literature review albeit the articles exclude the expression. They were found by using relevant terms e.g. mobility services or car-sharing etc. in databases, but these studies were not systematically analysed as described the 16 MaaS-related studies listed in table 1.

3. The roles of different transport modes and services in MaaS

The current role of different transport modes is expected to change to fit to service-oriented transport system of the future. This section describes MaaS-related changes in different transport modes and services. The section is divided three parts: cars, public transport and cycling. The section “Cars” discusses motor vehicles such privately own cars, car-sharing, car rental, and taxis.

3.1. The role of cars in MaaS

One of the key issues in MaaS is the role of a car. The fundament of new mobility services is the possibility to seamless and reliable mobility without owning a car (Ambrosino et al., 2016). Changes in car ownerships would probably mean more popular times for car-sharing. Car-sharing offers similar options as private cars but without ownership encouraging to try alternative modes, and when car-sharing is one of the alternatives instead of a private car, the actual cost of the trip is easy to compare to other modes (Huwer, 2004). Consequently, the different transport modes are at the same starting point when owning a car does not distort the choice of transport mode. Successful car-sharing service requires the crowd and is thus the most suitable in high-density urban structure (Giesecke et al., 2016). If there is often heavy goods or many children
to carry, owning a car may be a suitable choice, which needs to be considered when service providers and authorities develop new services (Mattioli et al., 2016).

Free-floating car-sharing is a modern model compared to station based car-sharing as free-floating service enables to pick up a car anywhere within operation area as long as the car is free, and to drop off the car within the same area (Becker et al., 2017a). The traditional station based service, in which the beforehand determined starting point and end point for a trip restrict the service, is assessed to affect more towards using sustainable transport modes than free-floating car-sharing (Becker et al., 2017a). Car-sharing in its alternative ways is anyway an important factor in the service concept, but as a separate service it does not provide revolutionary changes (Giesecke et al., 2016).

It is still unclear, who is going to own the cars in the future but someone has to be the owner (Hensher, 2017). Nowadays the majority of the cars are owned by households. Consequently, it seems unlikely or it at least takes several years before owning transfers widely to other actors e.g. car-sharing companies. Car-sharing companies of today may not be capable of owning very large numbers of vehicles, which could be the reason why private persons release their cars to joint use but still own the cars (Hensher, 2017). The quickly developing self-driving cars could change mobility considerably if they are utilized as a service. Pakush et al. (2016) estimated that some of the self-driving cars will be privately owned and rest of them used as a service, and this combination would reduce the amount of cars on roads. Present-day taxi services (e.g. Uber and Lyft) are already part of the transport system’s services but their business model may have too little upgrades compared to regular taxis for being a successful member of MaaS (Giesecke et al., 2016).

Decreasing car traffic causes positive impacts to climate and urban space and hence car ownership is an important question (Huwer, 2004). In itself, car-sharing is not more environmentally friendly than any other way of car usage as it also causes congestion but car-sharing companies typically offer newer and smaller cars than taxi services e.g. Uber (Giesecke et al., 2016). However, when cars are not privately owned, there is, supposedly, a bit higher threshold to travel by car than by other transport modes. In service-oriented transport system, driving a car, which can be in the form of car-sharing, can be managed better at the strategic level, which may reduce car traffic (Huwer, 2004).

3.2. The role of public transport in MaaS

The increasing use of private cars has created difficulties to conventional public transport during the recent decades (Ambrosino et al., 2016). At the same time, digitalization has made the use of buses and trains easier as electronic payment, web based route planning and real-time information has been introduced (Melis et al., 2016). However, conventional public transport needs to adapt in the new MaaS model as the current model is not that flexible to offer customer specified mobility, which is the basis of the MaaS model (Hensher, 2017). Reliable car-sharing and on-demand services may decrease the number of passengers in public transport but MaaS can also provide new ways to develop public transport. Fixed-route bus services with high service level are not cost-effective in rural areas, which leads to a lower service level and further lack of passengers (Atasoy et al., 2015). On-demand based MaaS scheme could be capable of providing sustainable transport also to low-density areas.

Typical model with geographic boundaries in producing public transport restricts the flexibility of public transport to act more as point-to-point service (Hensher, 2017). By using smart technology, flexible point-to-point services can be offered by demand-based systems together with conventional services with timetabled
routes (Hensher, 2017). As an advantage in flexible public transport, trip’s point of origin can act as waiting place and hence there is no need to wait on a bus stop. This may lead to an observation that flexible public transport seems to be more attractive also from car driver’s point of view than conventional public transport. (Frei et al., 2017) Adaptation of public transport to the model that fits in MaaS requires more experiences e.g. on how a service-oriented transport system affects people’s mobility. Travelling by a privately owned car could be reduced as new services can exploit real-time data on demand, thus produce enhanced service level of public transport and promote connectivity with other modes (Hensher, 2017).

How efficiently public transport can be integrated to other modes, is a crucial question for the future role of public transport. Hensher (2017) presented two scenarios including a combination of bus services and Uber-type point-to-point services, which is a possible scenario for the future as well as the combination of bus services and ride-sharing. Point-to-point services would consist of integration of conventional taxis and public transport. Ride-sharing would instead mean point-via-point-to-point services, which is more like conventional public transport than car traffic but the cost is lower. In ride-sharing, a small bus could replace a car if the amount of passengers is appropriate, but at the same time a fleet of small and large buses would add maintenance cost. It is however unclear, how these kind of solutions would affect the system and how bus contracts (e.g. share of profits) will be organized in MaaS model. (Hensher, 2017)

According to the experiences from Germany and Switzerland, car-sharing acts as a strong supplement for public transport and it also enables giving up car ownership, which further increases the use of public transport (Becker et al., 2017b; Huwer, 2004). Without car-sharing option, public transport oriented lifestyle could be difficult to maintain (Huwer, 2004). Furthermore, residential area’s enhanced accessibility has a connection to a decreasing number of privately owned cars and an increasing number of season tickets for public transport (Becker et al., 2017b). Purchasing a car or giving it up reflects a lifestyle change resulting in changes in mobility behavior (Huwer, 2004).

3.3. The role of cycling in MaaS

The discussion about the role of cycling under the MaaS model is missing in almost all MaaS-related literature. It has been mentioned that bikesharing is an important part of a comprehensive service system (e.g. Ambrosino et al., 2016; Kamargianni et al., 2016), but discussion has focused on other transport modes, especially on private cars, car-sharing, taxis and public transport. Yet, free-floating bike-sharing services offer an easy way to use bikes as the system includes several pick up and drop off points, and because of environmental aspects promoting bike-sharing is worthwhile (Tomaras et al., 2017).

Observations related to bike-sharing systems reveal that bike trips are typically short (usually less than 10 minutes) and this relates especially to most active users (Caulfield et al., 2017; Tomaras et al., 2017). Furthermore, active bike-sharing system next to fixed bus route has been assessed to decrease bus ridership in New York City (Campbell & Brakewood, 2017). However, in these studies bike-sharing has been studied as separate system from MaaS. It would be meaningful to understand the role of bike-sharing compared to expectable cornerstones of service system e.g. car-sharing and ride-sharing services. Current bike-sharing users would be likely users of MaaS as bike-sharing members have been assessed to be more willingness to try new services (e.g. flexible public transport) compared to others (Frei et al., 2017).

It is still unclear what will be the role of cycling as we are lacking proper knowhow of larger scale MaaS schemes. On one hand, bike-sharing services could increase the amount of cycling trips as bike can be
chosen for only one part of the trip chain and the bike is easy to access from multiple stations by using credit card or smart phone. On the other hand, car-sharing services offer easy access to automobiles, and ride-sharing services provide lower cost mobility. These are comparable choices for bike-sharing. Ride-sharing and demand responsive transport also offer more applicable pick up points for passengers compared to current public transport, which decrease the walking distances to access these modes. In conclusion, new services promote mobility possibilities in several ways, which make it hard to predict what is the future role of cycling.

4. Experiences of MaaS pilots and trials

This section introduces MaaS pilots and schemes or visions of them. The focus is on describing the experiences and effects of the trials discussed in the analysed literature. As a notable issue, the most advanced MaaS systems are still at a conceptual level or are just being introduced to the markets, making the amount of user experiences still low. Thus, there is not much literature available related to experiences of MaaS implementations, and to support the analysis, different MaaS systems are used as examples of the current state of the practice.

4.1. MaaS schemes

Kamargianni et al. (2016) stated that the highest level of MaaS scheme consists of ticket, payment and ICT integration and also provides mobility packages for customers. Advanced level MaaS systems like Whim, UbiGo, Tuup and SHIFT enable connecting different transport modes to an easy trip chain under a single platform (e.g. mobile app). The systems also allow the customer to plan applicable trip from point-to-point and to pay the whole trip at once or via package. These schemes integrate bike-sharing, car-sharing, car rental, public transport and taxis together. As an advanced system, Tuup’s taxi service, Kyyti, consists of on-demand taxis. Kyyti provides regular taxi with normal price but also cheaper shared taxi services with longer waiting and travel time. (Tuup, 2017) SHIFT also offered one form of on-demand taxis as SHIFT offered cars owned by the company with drivers (Project100, 2017).

Tuup and Whim, which are currently in operation, offer mobility services in Finland. Whim is next expected to expand the services in West Midlands (UK) and Amsterdam (Netherlands) (Whim, 2017). UbiGo had a six months trial in Gothenburg, Sweden, already in 2013 and second version of the trial is expected to run in other cities (UbiGo, 2017). SHIFT was introduced in Las Vegas in 2013 but the service has been discontinued (Project100, 2017).

Kamargianni et al. (2016) assembled different MaaS schemes world widely and created an index, which set up schemes based on the integration level (ticket, payment, ICT and mobility package integration). According the index, the higher the integration level and the higher number of transport modes included in the scheme, the higher is the level of the MaaS scheme. The study found 15 MaaS schemes and most of them got a comparably high score. In this index the so called Helsinki Model, a vision for the future, that Heikkilä (2014) presented, got the highest score. UbiGo and SHIFT were among the best in this comparison. Whim and Tuup were not included in the study, as they were not established at the time of the comparison but would presumably been ranked high.

Several other MaaS-related systems or applications have been created but they do not integrate the main transport modes to one system or the most critical integration (e.g. ticket and payment) is lacking and thus the
system is incomplete. A crucial part of future’s customized mobility options is demand responsive transport (DRT), which is already a part of Tuup’s application. Kamau et al. (2017) created Demand Responsive Mobility as a Service (DRMaaS) that is a transport service between taxi and bus services. DRMaaS was tested in Dhaka, Bangladesh, which indicated reduction in waiting time, and travel time was on average almost the same as by bus. The cost was more expensive than travelling by a bus but clearly more inexpensive than by other modes. Atasoy et al. (2015) developed simulation trial called Flexible Mobility on Demand (FMOD) service, which provide customized service to end-users, but the service system is not comprehensive as it solely consist of taxi, shared-taxi and minibus services. Flexible on demand transport called Kutsuplus was tested in Helsinki, Finland from 2012 until the end of 2015 (HSL, 2017). Even though ride-sharing minibus service Kutsuplus ended because of financial issues and scalability problems, the trial presented great potential for such a service (HSL, 2017).

One of the purposes of MaaS platforms is to make it easier to manage everyday travelling as our transport system with multiple mobility options is somewhat complicated (Hilgert et al., 2016). An example of that kind of a platform is a personal mobility assistance described by Hilgert et al. (2016). Furthermore, service platforms benefit service providers by enabling them to integrate needed external component (e.g. a bus tracking service) to the existing system, which could already include e.g. timetable services (Melis et al., 2017). A marketplace for mobility services called Smart Mobility for All (SMAll) introduced by Melis et al. (2017) is capable to integrate different data sources e.g. real-time transport data and pricing to enable trip planning for end-users and monitoring tool for authorities. The formation of a comprehensive service concept supports traveller’s daily mobility in the terms of starting and ending time information of the trip with appropriate cost and travel time combined to intelligent ways to share information between transport operators.

4.2. Experiences of MaaS trials

As the current amount of comprehensive MaaS-schemes is low and some of them are newly established, there is not much data related to user experiences. UbiGo’s trial is one of the few high-level schemes that has published questionnaire data on participants’ experiences. Survey data of 151 users of the UbiGo pilot revealed that the participants increased their use of car-sharing and public transport while decreased their use of private cars during the trial. The trial integrated several transport modes under one payment package. An interesting detail is that customers overestimated their need to use car-sharing service as they purchased more car hours than they used during the trial. This could be a result of changing car trips to other transport modes. (Karlsson et al., 2016)

Almost all of the participants would have been interested in carrying on using UbiGo after the end of the pilot. It was mentioned that the service, which was used through mobile app, caused problems to some customers and thus help desk via telephone and even special guidance meetings were worth to be arranged. To sum up, users became more negative towards private cars and more positive towards alternative modes due to UbiGo trial. (Karlsson et al., 2016)

MaaS enhances user acceptance compared to time before the services. Without a MaaS bundle, the availability of various mobility options and flexible working conditions cause difficulties to choose a trip chain (Hilgert et al., 2016). Particularly “high-level” MaaS schemes with multiple modes and integration of necessarily attributes are expected to increase the demand for the new service concepts (Kamargianni et al., 2016). A key issue is to manage user’s travel behaviour in a better way with these new tools (Hilgert et al., 2016).
Mobility trials can have an enormous role in changing people’s mobility patterns. Even though a person may have an intention to change one’s mobility behaviour to a more sustainable direction, it is, however, difficult to evaluate actual results of the change to personal life and this is why trials enable a safe way to try new modes (Strömberg et al., 2016). Especially, to give up owning a car and to adopt new mobility services causes hesitation and consequently mobility habits could remain as before. The trials have indicated that people’s preconceptions have altered after the trial but it is important that duration of the trial is long enough (e.g. six months) in order to change mobility behaviour (Strömberg et al., 2016). Mobility service apps can also suggest to add sustainable behaviour (e.g. walking and cycling) to trip chains and thus encourage people to a healthier lifestyle (Melis et al., 2016). Apps and trials could have even a larger impact if they are considered as a strategic tool to modify everyday mobility (Strömberg et al., 2016).

The trials are an important step to change the paradigm but they also reveal challenges related to the MaaS system. First of all, careful planning is required to combine different services and transport modes offered by different operators into one MaaS scheme (Kamargianni et al., 2016). Furthermore, the end of the trial should not be the end of the MaaS scheme as long as user experiences have been positive (Karlsson et al., 2016). As public transport, which could be subsidised by taxes such in case of UbiGo, plays a crucial role in MaaS, support from policymakers is needed to ensure enough funding and necessary regulations for a permanent system (Karlsson et al., 2016).

As MaaS should be able to compete with the current car-based system, it is important to develop the quality of the MaaS scheme enough before beginning to operate. International standardization of data-formats and APIs (application programming interfaces) is also required in order to provide technical possibilities (e.g. integrated services) for the background system of MaaS (Melis et al., 2017). Expansion of the business to other countries is another challenge but internationalisation is more likely to happen after successful implementation in one country.

5. Effects of new services

Changes towards a service-oriented system have an impact to the whole transport system and the users utilizing it. As MaaS system is not yet widely and consistently adopted anywhere, the impacts described in this section are based on observations of smaller projects and enlightened assessment. In the new paradigm, future transport system is created in a smarter way than by building new capacity and the convenience of a private car can be maintained without the burden of ownership (Hietanen, 2014). MaaS seems to be a desired model from society’s point of view as it offers more efficient use of transport modes and their combinations mean more efficient use of the infrastructure, which further promotes cost-efficiency of investments already done (Rantasila, 2016). Furthermore, the possibility to combine travellers’ needs and to supply public transport services more cost-effectively may reduce the demand for public subsidy to public transport (Hensher, 2017).

In order to get people change their current role from transport providers (driving a car from point-to-point) to customers (using mobility services), MaaS is required to be capable to fulfill the daily mobility needs. Actually current transport systems is already providing options to different needs since public transport is appropriate for many daily trips, taxis and bicycles provide flexibility to more specific individual needs, and car rental and sharing services cover the rest of the mobility needs (Huwer, 2004). Service-oriented system combines these different modes and services on behalf of the customer e.g. by creating instructions on what to do to reach the desired destination and thus different mobility options are becoming easier to use. As added value of MaaS, trips are planned by a digital app (Hensher, 2017).
Anticipation for the development of the transport system is challenging as we can solely estimate how the novel technologies and social behaviour e.g. autonomous vehicles, car-sharing, ride-sharing etc. will affect mobility (El Zarwi et al., 2017). Despite the recent hype related to e.g. autonomous vehicles, we have not that much understanding, whether people are going to adopt and utilize these vehicles in larger scale. El Zarwi et al. (2017) presented a prediction model for the new technology adoption. According the model, one example of a successful way to find customers for car-sharing, which is expected to be in an important role in MaaS, is to set a car-sharing station next to a larger technology company. Furthermore, men and high-income groups were estimated to have a positive attitude towards new technology. These findings provide valuable knowledge on the things that are useful to consider when acting as a service provider or running the whole service system.

The most evident change because of MaaS seems to be in the role of car as Hensher (2017) stated based on previous literature. Changes in car ownership could, for example, mean a reduced demand of parking space, which enables new possibilities for land use, and particularly creates space for something else (Rantasila, 2016). However, it is not fully clear that change in car ownership would mean less demand for car parks and decreased level of congestion. As a consequence of MaaS, more efficient use of existing vehicles would decrease the traffic volume, but better services for individual mobility (e.g. for disabled people) could mean increased traffic and eventually more congestion than in the current system (Rantasila, 2016). Since only a few studies related to intelligent mobility services have focused on environmental impacts, the sustainability of MaaS requires more research (Brendel & Mandrella, 2016).

Ownership itself is not the difference maker in the terms of popularity of car travelling if the car-sharing and taxis are easy and affordable choices compared to others. However, the use of sustainable modes could increase in principle, when a private car is not all the time ready to depart right at the forecourt. When people are not “forced” to use car, they can better choose the transport mode that fits their individual requirements (Karlsson et al., 2016). If people choose to replace conventional timetabled public transport services during peak hours with a flexible car-sharing services, congestion is still likely to remain (Hensher, 2017).

In order to work properly, the service-oriented transport system demands actions from the public administration. It should be ensured that the roles, responsibilities and collaboration regarding mobility operators and institutes that are in charge of the whole system are appropriate from mobility services point of view. The public administration itself could act as an upper level organizer and thus would be responsible of the collaboration of operators or the role of central MaaS operator could be given to private companies (Melis et al., 2016). Anyway, as public transport is expected to play a key role in the new paradigm, the public transport authorities are key stakeholders as a one of the upper level MaaS organizers (Ambrosino et al., 2016).

As individual mobility data becomes an integral part of service development and daily transport, information security and privacy are increasingly important factors to recognise. Melis et al. (2016) state that the privacy of customers should be secured more reliably when the service system is led by public administration, while private companies in charge could lead to uncertainty in data collection and its usage, even though market-based mobility services also create benefits. Another information security aspect is Denial-of-Service attacks, which would affect the society widely if mobility is increasingly dependent on data systems (Thai et al., 2016). Moving towards self-driving cars would even emphasize this aspect, when abusers could affect the safety and road traffic.
6. Discussion and conclusions

Based on the literature review Mobility as a Service could be defined as a concept in which individual mobility needs can be fulfilled effectively and more sustainably than currently by integrating different transport modes and services to seamless journeys. This requires an open platform for cooperation of various mobility operators. If regulation of transport will be updated to meet operating conditions of MaaS, service supply is expected to expand considerably (Hensher, 2017). As a new approach to mobility, service-oriented transport system demands adjustment from users, operators and public administration.

Applicable and sustainable MaaS system requires well-planned functions and also a strong support from policy-makers and other stakeholders. Kamargianni et al. (2016) stated that integration of ICT systems, ticket and payment system, and pre-pay option are prerequisites for a successful MaaS implementation. This means that one ticket or smart card has to be applicable in every transport mode and there could be a possibility to buy a specific amount of time or distance of mobility services in advance (Kamargianni et al., 2016). Bookable on-demand services (e.g. shared-taxi), which are a part of the comprehensive MaaS concept, include inconveniences compared to private cars, which is a reason why MaaS needs to offer other benefits like avoiding congestion because of appropriate start time giving by the booking system (Lamotte et al., 2017). The new concept should not only include existing transport modes but also offer better circumstances (e.g. better service level or lower costs) simultaneously (Giesecke et al., 2016).

MaaS is a new concept and the amount of MaaS-related scientific articles is currently low. However, it is a hot topic as most of the MaaS studies were published in 2016 or 2017. Taking into consideration the relatively low amount of articles and papers, all the recognized scientific publications could be analysed in this study. Currently, in 2017, we can identify the early stages and ideas of a Mobility as a Service. Based on the literature, MaaS is identified and estimated to have wider scale impacts on mobility and transport system such as:

- Services make transport system more efficient and help to recognise and choose daily mobility options
- Personalized services enable seamless trip chains by integrating different transport modes
- Popularity of the private cars is expected to reduce as flexible choices such as car-sharing and on-demand ride-sharing services become more common
- Currently the actual cost of car travelling is difficult to determine but mobility services, including car-sharing, simplify cost comparison of different transport modes
- Sustainable transport modes are expected to become more popular albeit there is not much discussion of the role of cycling in the MaaS literature
- New flexible transport modes force conventional public transport to adapt to a more service-oriented system
- MaaS trials enable great possibilities to get to know and try out the new mobility services
- Public sector has a key role as an enabler of MaaS e.g. by supportive legislation.

In this study, current state-of-the-art MaaS-research was assorted to three groups. As MaaS consists of various transport modes, it is natural that in many articles the discussion is done from point of view of specific transport modes and services. Particularly, the role of cars, including e.g. car-sharing, is discussed widely. The role of conventional public transport and its integration to new services are also covered in many ways. Several studies also describe MaaS as a concept and try to explain its meaning. In the future, society, land use and transport system points of view would be important to cover more thoroughly in order to understand the
comprehensive impacts caused by the different sub-impacts, e.g. the integrated effects of transport modes. As another aspect to expect integrated research on is how highly automated and self-driving cars will affect MaaS and connect to it and further to the whole transport system.

In conclusion, the scientific community has quite little knowledge about actual effects following from MaaS because first large-scale implementations are about to start in 2017. As the next step there is a need to analyse mobility data provided by private companies or in some cases public administration, to study the new paradigm more deeply. That may be a challenge as private companies’ willingness to share the data is not clear. As Giesecke et al. (2016) stated, we also need research about the roles and responsibilities of MaaS stakeholders currently and in the future. Furthermore, more sustainable transport is one of the possible outcomes of MaaS, but researchers need more knowledge on why users decide to choose more sustainable mobility (Brendel & Mandrella, 2016). As new transport modes (e.g. car-sharing and ride-sharing) become more popular these modes should be included in travel surveys in order to get more detailed data of their use (Frei et al., 2017).

Today, travelling by a private car is a significant issue in our transport system. MaaS concept, however, aims to change that pattern by encouraging to use mobility services. It is interesting to see if the desired service-oriented system is tempting enough to make people change their mobility patterns and give up private cars. All in all, the role of ownership and motoring under MaaS is an interesting and justified topic for future research. Households, which do not own cars or with several people but one car, have probably the highest interest towards MaaS at the early stages of implementation. The role of cycling in service-oriented system is another topic, which should be covered more widely. As a MaaS has the potential to change mobility patterns notably, it will be an interesting topic for further research and scientific publishing.
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Platforms and frameworks
Regulation and Governance Supporting Systemic MaaS Innovations – Towards Innovation Platforms

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Abstract

Mobility as a Service (MaaS) is an example of a systemic innovation, where sustainable mobility services addressing different customers’ transport needs are integrated with traveler information and ticketing/payment services. In our current research project, ENSCC Smart Commuting, we have examined how the differences in national regulation, stakeholder processes, and geographical characteristics have resulted in different approaches to regional governance when supporting different sustainable mobility solutions.

Public-Private-People-Partnership processes and clearly defined roles are essential when supporting systemic innovations. Growth Corridor Finland (GCF), a collaboration network comprising municipalities, ministries, chambers of commerce and private companies of the region, uses a common vision process and quick experiments to find out the optimal solutions for regional needs. There are several similar collaboration networks in the Basel metropolitan area such as Agglo Basel and the Trinational Eurodistrict Basel. These Swiss networks integrate the interests of more than 80 municipalities/cities and their thematic focuses include transportation and spatial planning.

In the field of transportation, these networks aim at promoting cross-regional mobility solutions and becoming innovation platforms for new smart and sustainable mobility solutions. The purpose of this paper is to describe the experiences of different stakeholders from this collaboration and how these formal collaboration networks could enhance stakeholder participation when progressing with their aims.

KEYWORDS Governance, Stakeholders, Transportation, Collaboration platforms, Case study

1. Introduction

We are currently experiencing a transition in how people conceive the need of owning a car or what is public transport. Especially the development of open data and mobile information platforms are changing the way consumers perceive public transport services (ITF, 2015). For example, the rising popularity of car-sharing (Shaheen & Cohen, 2016) in Europe has added real options for customers in supplementing mass transit services. These new services are enabled and powered by a variety of societal, economic, technological and consumer-related trends, such as urbanization, congestion in large cities, and environmental issues of traffic (e.g., Tinnilä & Kallio, 2015).

The role of regional authorities is also viewed differently in this transition. Some regions and countries in Europe emphasize the policy objectives of public transport authorities such as economic growth, space optimization, aesthetic impacts, congestion, social inclusion, and citizen well being (e.g., Polis, 2017). Others see private mobility service operators and Mobility as a Service (MaaS) offers as a vital part of accessibility and connectivity in the regions facing economic austerity (e.g., MaaS Alliance, 2017). Both of these viewpoints call for transparency and broad stakeholder participation in the development of the transportation
ecosystems. Formal collaboration networks can help with aligning these different objectives, make cross-regional mobility solutions possible, and promote smart and sustainable mobility innovations.

In our current research project, ENSCC Smart Commuting, we are looking into the mobility needs and mobility behavior of workers since mobile workers and commuters usually are the first customer segment to whom tailored mobility services and mobility as a service are offered. We have used sociotechnical analysis to describe the context of this technological and behavioral transition. The differences for example in national regulation, stakeholder processes, and geographical characteristics have also resulted in different approaches to regional governance of transportation systems. The aim of our recent survey and the purpose of this paper is to describe the various viewpoints of stakeholders and how collaboration networks could align these views. Our analysis of the sociotechnical regimes in Finland and Switzerland are discussed after this introductory chapter in Chapter 2 and our survey to stakeholders is presented in Chapters 3 and 4. Our paper ends with conclusions and recommendations for transparent stakeholder participation in the development of sustainable mobility solutions.

Mobility as a Service (MaaS)

From the viewpoint of single transport operator, new mobility services can be seen as competing offering, but many of the regional transport authorities are already considering the sustainability of the whole public transportation system. While the role of cities and regional transport authorities in this transition is under debate, the consensus is that these innovative services are needed to supplement traditional public transport services in this technological and behavioral transition. Mobility as a Service (MaaS) is one example of these emerging services. From a customer perspective, MaaS increases the transportation alternatives and modes available to them, as well as new digital services for effective and efficient planning and use of these various travel opportunities. In the long run, MaaS may also have impacts on city planning, land use, the role of public organizations and welfare of citizens. For this reason, this new concept has gained growing interest among all the stakeholders: consumers, politicians, academia, transport operators, software developers, etc.

Private MaaS companies are currently starting their operations in urban areas with larger customer bases, but demand-responsive transport is also seen as one of the key options to meet public transport challenges in rural areas (ITF, 2015; Hazan et al., 2016). Regions and countries with strong natural transportation monopolies see similar increase in mobility services, but usually, they are part of the service offering of these natural monopolies. Regardless of the organization of these new services, MaaS in this paper is used to describe the change from mobility as self-service and independent development of different transportation modes to a genuinely integrated mobility made possible by new digital services.

Institutional change and socio-technical regimes

Mobility as a Service is an institutional, and systemic change in mobility, transforming both customer experience and utilization of physical resources. By institutional we mean that it requires changes in institutions, which “are the rules of the game in society, or more formally, are the humanly devised constraints that shape human interaction” (North, 1990). Systemic refers to a paradigm shift, with an emphasis on the interrelationships and interdependencies among the parts of the system.

To understand the underlying changing factors in institutional change, Kingston and Caballero (2009) compared a variety of theoretical approaches to conceptualizing institutional change. One of the identified
factors affecting change is the role of politics and collective action, which makes this work essential for our empirical paper. Kingston and Caballero (2009) also list the role exogenous (formal or informal) influences, endogenous processes, path dependence, the pace of change, and bounded rationality of the actors as influencing factors. In our analysis, we have used the socio-technical system (Geels, 2004) to illustrate the exogenous forces operating in the system, the path dependence of institutional change and the pace of change. This approach has allowed us to focus on the endogenous processes such as politics and collective action and the bounded rationality of actors due to communication challenges in our recent survey.

The role of innovation platforms

There is empirical evidence of the importance of stakeholder participation when implementing systemic innovations to different contexts. For instance, Schaffers and Turkama (2012) explore the transferability of systemic innovations in home care and independent living, energy efficiency, manufacturing networks and citizen participation. According to their findings, living labs approach can be used for cases that call for user-behavior transformation or business-model innovation. Living labs are by nature local, addressing the needs of specific demographics and developing suitable solutions to these requirements. And while different MaaS offerings have also so far been local, or at most connecting separated islands of urban mobility (cities) to the same offering, Kulmala and Tuominen (2015) points out that a highly efficient and productive transportation system is an essential part of regional competitiveness, overall economy and people’s quality of life. This aim enlarges both the context and stakeholder network (Figure 5) of sustainable mobility services beyond the scope of traditional living labs.

On the level of single modes, such as car sharing services, there are already established global enterprises from the car rental and car manufacturing industry that are looking for the bigger picture. With MaaS, we may witness the first nationwide offering to surface this year in Switzerland (PostBus, 2017). Interest groups, such as MaaS Alliance, aimed at developing standards, shared principles, and European wide approach to MaaS. The question remains what is the best way to align the different interests and ensure transparent stakeholder participation in the regional and national levels, which are natural extensions of the urban pilots of today?

Based on our earlier experience on innovation platforms (e.g., Malinen & Haahtela, 2010) we chose to do comparative analysis on the regional collaboration in Switzerland and Finland. The collaboration networks in these regions (Trinationaler Eurodistrict Basel and Growth Corridor Finland) share the principles of openness and inclusivity, meaning that they are open to all service providers and inclusive for all kind of users, but there are clear differences in the governance of transport systems (Chapter 2) and the role of regional transportation authorities in these two countries/regions. These networks have a history in spatial planning, transportation system development and ensuring the economic vitality of the region, but there are definite indications that supporting innovations in these thematic areas are becoming an essential task of these networks.

One of the reasons for the importance of this task is that accessibility and connectivity in regions is an environment that is fragmented and hostile to innovation. The governance styles and transportation subsidies in different independent municipalities do not allow market players to compete and establish business models that bring demand and supply into a natural balance. Thus, according to Arthur D. Little’s Future Lab (Van Audenhove et al., 2014) what is needed is a regional-level collaboration between all stakeholders of the mobility ecosystem to support innovative and integrated business models. As the lack of synergies between
isolated MaaS pilots leads to a sub-optimal outcome regarding mobility performance, there is a need for innovation platforms that integrate different mobility systems while ensuring that new solutions are adapted to local contexts.

With this latest task of regions and countries, tight regulation may not be the best starting point. The experimental economy needs speed, flexibility and positive attitude toward new initiatives, even if they might affect some traditional business areas negatively. To exploit the opportunities connected to servitization of mobility, public authorities should create an innovative environment (Finnish Transport Agency, 2015) regardless of the governance style in the region.

2. Socio-technical regimes

We use in-depth case comparison between different concrete contexts of action and interaction and interests of real actors involved. By context, we mean the socio-technical regimes in Switzerland and Finland. Specifically, we have examined how legislation, governance styles, and technology development influence different systemic innovations in these countries.

Finland

Finland has a two-level administration: national and municipality level, and the legislation is the same everywhere. As parliament and town councils change every four years after the elections, different topics in transportation become prominent and get funding. On the other hand, many issues and decisions in transportation become topical because of current EU directives and their preparation.

Several overlapping policies and legislation changes guide the changes in Finnish transport sector. These legislation reforms are such that are supposed to progress regardless of the government and dictate the development in transport sector during forthcoming years. Currently, the three most influential Finnish policies and legislation changes for MaaS are:

1. Climate strategy: Finland’s goal is to reduce greenhouse gas emissions 80–95% compared to 1990 levels by 2050. The role of the transport sector in reducing emissions is highlighted in the new the National Energy and Climate Strategy (Ministry of Economic Affairs and Employment, 2017) as road transport produces 90% of the greenhouse gas emissions of domestic transport and reducing emissions in other sectors are relatively complicated. According to the strategy, this reduction in emissions is achieved by the proliferation of electric cars, biofuels, and sustainable MaaS solutions.

2. New transport code (in act 1.8.2018) aims at responding better to the needs of transport users through enabling digitalization and new transport services. The objective of this reform is to promote the creation of new service models, ease market entrance, dismantle national regulation that limits competition and reduce the level of public guidance.

3. Legislation reform for Finnish Road Traffic Act aims for better alignment with EU legislation, increase road safety, and cover autonomous vehicles and new types of lightweight vehicles in the new act.

The major players in national level related to mobility are Ministry of Transports and Communications, Finnish Transport Agency and Finnish Transport and Safety Agency. The Ministry of Transport and Communications is in charge of implementing the intelligent transport strategy and is responsible for allocating sufficient resources to it within the transport administration sector. The Finnish Transport Agency is in charge of 1)
ensuring the availability of services in major urban areas and 2) continuity across administrative boundaries, as well as 3) responsible for the overall intelligent transport architecture.

Cities and municipalities are responsible for organizing local public transport services in Finland. However, only certain school and social welfare transports are legally mandatory to organize everywhere. This means, in practice, that only the largest cities have excellent public transport services while the service level in rural areas is not that good, and a private car is by far the most common mode of transport in these areas. The larger cities are also drivers for most of the development in public transportation, as smaller municipalities do not have enough resources for the development.

With so many different public authorities tendering or organizing local public transportation, the transport operators and companies in Finland mainly have incompatible IT systems. However, Finnish Transport Agency is opening all the data it produces, and the new transport code includes measures for support open data and interoperability. These steps include making interoperability through API’s a criterion for public procurement. However, before these changes are in effect, organizing public transportation especially in rural areas remains to be a challenge with continuously diminishing population and passenger numbers, and difficulties in combining the legally mandatory transport services more sustainably.

GROWTH CORRIDOR FINLAND (GCF)

As a geographical area, Growth Corridor Finland stretches from Helsinki to Hämeenlinna, Tampere and Seinäjoki region as a string of cities. Economically, it forms the forefront basis of national competitiveness; more than 50% of Finland's GDP is produced in this area. Growth Corridor Finland is also the biggest pool of workforce in Finland with more than 300,000 daily commuters. The distances between the urban areas are long and compared to urban areas in central Europe, the population density is low outside capital region of Finland (Figure 1).
As a collaboration network, the Growth Corridor Finland comprising of over 20 cities and municipalities of the region, three regional councils, four chambers of commerce, four ministries and the Federation of Finnish Enterprises. The development of new transport services and MaaS concepts are essential to GCF (Figure 2) and Finland. For GCF these new mobility services are an important part of the accessibility, attractiveness, and vitality of the whole region. One of the objectives of the collaboration network in Growth Corridor Finland is to become the leading experimental platform on intelligent transport services and systems in Northern Europe. On a national level, the Ministry of Transport and Communications in Finland has pointed out in its press release (Ministry of Transport and Communications, 2017) that Finland’s greatest opportunities lie in the quick and comprehensive adoption of technological solutions being created globally.
Figure 2: The most recent mobility services implemented by private companies in Growth Corridor Finland. Picture copyright Growth Corridor Finland. Picture used and modified with permission.
Switzerland

Switzerland is a welfare country with high-quality infrastructure and public transport. Traditionally Switzerland has invested into a high-quality railroad service, and as a result, the number of kilometers traveled per inhabitant in a year on rails – around 2500 km – is highest in the World. The total length of the railway network is more than 5000 km, and the highway network is significant with more than 1800 km of highways. Given the population (8.5 million) and the area (41 000 km2) of the country, these transport infrastructure numbers are impressive.

Switzerland’s history and the system of government are entirely different compared to other western countries as it is a confederation, where cantons, districts, and municipalities have relatively more power in contrast to the Federal Government. Tasks, which do not expressly fall within the responsibilities of the Federal Government, are handled at the next level, i.e., by the Cantons. Therefore, different kinds of transport services can be legal or illegal in various parts of the country. Also, since Switzerland is not part of the EU, it also has more leeway in legislation.

One of the seven departments of Federal Government is Federal Department of Environment Transport, Energy, and Communications (DETEC). The Federal Government has set DETEC a primary task to “assure the sustainable provision of primary services in Switzerland … to meet present requirements for infrastructures and at the same time to secure for future generations the chances of an intact environment” (Federal Department of the Environment, Transport, Energy and Communications, 2017). While Cantons have most of the legal power in transportation, DETEC, by its decisions and support to natural monopolies in Switzerland (e.g., Swiss Federal Railways and PostBus) has had an influential role in the development of the Swiss public transport.

Of the Swiss population, around five million people live in the five most significant city regions: Zurich, Geneva, Basel, Bern, and Lausanne. All these city regions have high-quality public transport systems with undergounds, trams, buses and local trains as well as several different last-mile mobility solutions including different car sharing service models, city bikes and excellent cycling possibilities with ride’n’park facilities. Outside these city regions, Swiss Federal Railways and PostBus take care of the long-distance transportation and accessibility of rural areas. These two transportation companies connect the whole country by a ‘clockface’ timetable approach. This approach means that every single public transport system and service is synchronized according to the railway schedules – and working like a Swiss clock.

From the perspective of new transportation services, this Swiss approach to organizing public transportation is a double-edged sword. It is possible to do different short-term demonstrations as most of the 26 cantons have resources and willingness to try various new services. The downside is that countrywide solutions require a lot of resources, especially for small startups, when all the different rules need to be analyzed and negotiated with each of the Cantons. Also, changes in legislation in one single canton can endanger the countrywide service promise.

However, the single most significant challenge for new transportation services to establish themselves in Switzerland is the subsidized and already existing high-quality public transport. Cooperation with different stakeholders is challenging, as the federal and local natural monopolies have the opportunity to restrict the use of their resources (infrastructure, timetables, booking systems, IT, etc.). As a result, a pragmatic way to establish a new transport service in Switzerland is to a) sell the concept to some of the large cities (for
city-related services) or b) to cooperate with either Swiss Federal Railways or PostBus, and hope that these companies incorporate the service as a part of their countrywide service portfolio.

TRINATIONAL EURODISTRICT BASEL (TEB)

One of the collaboration networks in Basel-travel-to-work area is TEB or the Trinational Eurodistrict Basel, which is a joint spatial and transportation system planning organization consisting many of the municipalities, cities and regional authorities in the region (Figure 3). The population density, the size of municipalities around Basel city and the network of railway lines differ quite much from the situation in Growth Corridor Finland. Although some people commute across country borders on their way to Basel, designing efficient transportation infrastructure in and around a dense metropolitan area is more straightforward task than in Growth Corridor Finland. However, since Switzerland is not part of the EU and it does not have the same rules regarding public procurement, the development and operation of public transportation in this region require shared vision and collaboration organizations such as TEB.

![Population density and railway lines in Basel travel-to-work area](image)

**Figure 3:** Population density (municipalities not participating in TEB are white) and railway lines in Basel travel-to-work area. Thickened lines are the country (France - Germany - Switzerland) borders in the region. Picture copyright Aalto University.

One of the tools used in the Basel metropolitan area is pendlerfonds, which promotes projects that help to reduce the parking pressure on the city center and facilitates public transport by constructing park-and-ride and bike-and-ride facilities in the neighborhood (Figure 4). The funds for these projects comes from the gross income from commuter and visitor parking tickets in the Basel city.
3. Survey

To deepen our understanding of the transformation potential of mobility innovations, the perceptions of different stakeholders were surveyed in both of our study areas. Before the survey, various stakeholder categories (Table 1) were identified by analyzing the stakeholder network of the Basel metropolitan area. This network was constructed by mapping the participants of 61 different stakeholder processes such as pilot projects, strategy development groups, academic projects, infrastructure projects, etc. in the theme of mobility and commuting. Altogether 268 stakeholders were identified this way (of which 210 could be contacted for the survey). In Basel area, also the connections between stakeholders during these processes were mapped to understand their overall embeddedness in the formal stakeholder network (Figure 5).
Figure 5: Stakeholder network of the Basel metropolitan area
Table 1: Stakeholder categories used in the survey analysis

<table>
<thead>
<tr>
<th>Category group</th>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration</td>
<td>Public administration</td>
<td>Four different sub-levels were distinguished here: National, Canton/Bundesland/Département/County, Regional, Municipal</td>
</tr>
<tr>
<td></td>
<td>Regional cooperation platform</td>
<td>Publicly funded platforms/organizations which focus on cooperation on a regional level (e.g. TEB)</td>
</tr>
<tr>
<td>Associations &amp; NGO</td>
<td>Chamber of Commerce</td>
<td>Chambers of commerce as representatives of businesses</td>
</tr>
<tr>
<td></td>
<td>Citizen group</td>
<td>Interest groups representing citizens, often based in a certain city quarter</td>
</tr>
<tr>
<td></td>
<td>NGO and lobby</td>
<td>Non-governmental organizations and lobbying groups, often legal associations or foundations, who promote and support specific development directions</td>
</tr>
<tr>
<td>Industry</td>
<td>Company / industry</td>
<td>Industry representatives or companies which don’t offer mobility services (see “Transport company” below)</td>
</tr>
<tr>
<td>Planning &amp; Research</td>
<td>Consulting and planning</td>
<td>Private research, engineering, consulting and planning offices</td>
</tr>
<tr>
<td></td>
<td>Research institution</td>
<td>Public research institutes (e.g. universities)</td>
</tr>
<tr>
<td>Political party</td>
<td>Political party</td>
<td>Political parties</td>
</tr>
<tr>
<td>Transport company</td>
<td>Public transport company local</td>
<td>Local providers of public transport</td>
</tr>
<tr>
<td></td>
<td>Public transport company national</td>
<td>Provider of public transport on a national level, e.g. national railway company</td>
</tr>
<tr>
<td></td>
<td>Public transport company regional</td>
<td>Provider of public transport on a regional level</td>
</tr>
<tr>
<td></td>
<td>Transport association</td>
<td>Consortium of different public transport operators providing homogenous services</td>
</tr>
<tr>
<td></td>
<td>Transport company (other)</td>
<td>Providers of transportation services such as taxi, car sharing, bike sharing etc.</td>
</tr>
</tbody>
</table>

The Finnish sample was collected similarly with 130 stakeholder representatives identified from the participants of public stakeholder processes such as pilot projects, strategy development groups, and infrastructure projects done in the Growth Corridor Finland region during the past five years. These 130 representatives were supplemented with 70 stakeholders looking mobility and commuting on a national level to have survey responses from all the identified stakeholder categories from Finland as well.

With 99 completed questionnaires, the overall response rate was 24.1%. Whereas the samples do not claim to be representative for absolute quantitative evidence, the survey still points out differences in perceptions and attitudes according to stakeholder groups as well as to the two different sociotechnical contexts.
Based on previous expert workshops organized in our research project, we chose the following themes to be covered by the survey:

- Stakeholders’ experiences in cooperation processes,
- Stakeholders’ perception of the supporting factors and challenges/barriers in implementing mobility innovations,
- Stakeholders’ general attitudes towards certain mobility innovations, and
- Stakeholders’ potential active roles in the ongoing development and implementation of MaaS offerings.

4. Results

Stakeholders’ attitude towards MaaS

In the first section of the survey, participants were surveyed regarding their general attitude towards MaaS. What became apparent is that all stakeholders without any exceptions see MaaS concepts either neutral or positive development in transportation. In Finland, more than half of all stakeholders state that they actively support MaaS (Figure 6), around 30% approve it and about 10% are neutral towards this new concept in mobility. In Switzerland, the attitude towards MaaS is also favorable, yet less enthusiastic than in Finland: around 30% of Swiss Stakeholders are actively in favor of MaaS, about 40% approve it, and approximately 30% are neutral.

When looking at the responses between stakeholder category groups, the results differentiate a bit more. Especially “Industry” representatives show a significant acceptance for MaaS. This may be because innovations can create new markets and make room for new business models from which these industry-actors would benefit even though they do not offer transportation services themselves. In contrast, stakeholders in the category “Administration” and “Associations and NGOs” show below-average enthusiasm compared to other stakeholders.

![Figure 6: Stakeholders’ attitudes towards MaaS according to stakeholder category and country](image)

The stakeholders were also surveyed regarding two specific aspects regarding their opinion towards MaaS. First, whether they see MaaS as important for their own (business) activities, and second, if they see MaaS as relevant for the future commuting and mobility in general. It became apparent that the overall positive attitude
and openness towards MaaS persists in these situations, especially regarding stakeholders’ opinion that MaaS will be relevant for future commuting schemes (Figure 7). The results are very similar in Switzerland and Finland, and in both countries over 35% of stakeholder consider MaaS a mobility offer, which will become very relevant for future commuting schemes.

In contrast, the estimations regarding relevance for stakeholders’ activities differ between the two countries. In Switzerland, a higher share of stakeholders (around 33%, see Figure 7) consider MaaS to be very relevant for their own (business) activities. In Finland, this share is lower (14.5%). However, over 40% of the Finnish stakeholders state that MaaS is “rather relevant” for them. Only 18.2% chose this category in Switzerland.

Figure 7: Relevance of MaaS for future commuting schemes in general (left) and for stakeholders’ own activities (right).

When presenting these two factors in one diagram (Figure 8), it becomes apparent that Finnish stakeholders rate MaaS more relevant for future commuting schemes than for their activities in commuting. In Switzerland, the results are more evenly distributed: those stakeholders considering MaaS important for commuting see it also more important for their activities and vice-versa. This could indicate that Finnish stakeholders act and think more based on promoting systemic innovations than on their immediate interests.
Supporting factors and barriers

To create successful innovation platforms, it is necessary to have a profound knowledge of which frame conditions are considered supporting a technological implementation or whether they are currently considered as challenges. Therefore, the survey respondents were asked to what extent they think certain frame conditions to be supportive factors, assuming that these conditions are satisfied. At the same time, they had to evaluate, if these conditions are still challenges or not. These results are evaluated together in one diagram (Figure 9).

The consolidated analysis revealed that especially the factor “state of technology development” is considered being an essential part of implementing new technologies. If the technology is not developed enough, the innovation cannot be fully exploited. Correspondingly, a working proof of concept is seen as an influential supporting factor.
Interestingly, the factor that is considered being the least supportive is “economic viability”. This may be an indication that stakeholders could envision making investments in new technologies, even if their return on investment is not yet known.

Currently, the respondents are considering all queried factors still as challenges, however, generally on a low level. The factor “policy and legislation” is rated as the factor representing the most significant obstruction for implementing new technologies. The stakeholders also state that the collaboration and communication with other stakeholders do not present a considerable challenge. This may be because stakeholders could imagine implementing innovations on their own, or that collaboration between stakeholders is expected to be easy. To dig in more in-depth on this issue, we asked respondents to tell us positive and negative experiences from this collaboration using open text fields.
Positive and negative experiences from collaboration

The most significant finding in the Finnish survey data is the enthusiasm showed towards new mobility solutions and cooperation. This enthusiasm was the most common description that respondents gave as an answer to the open question about their positive experiences during collaboration process. The respondents also stated that Finland is a relatively small country where different stakeholders know each other. Common to Finnish stakeholders is also their willingness to cooperate, and they perceive that essential themes and development activities have been recognized during these collaborations. This shared vision is considered to create a good background for the forthcoming change. The cooperation experiences between different stakeholders are mostly positive.

On the downside, Finnish respondents are of the opinion that some changes happen quite slowly. There are also some stakeholders who are more conservative than others; the difference between forerunners and laggards is perceived to be significant. For example, some of the stakeholders state that cooperation with Finnish natural monopolies in transport is not fluent enough. Overall, according to the survey answers, there are various opinions and ideological differences about what should be the role of the public sector in this paradigm change. Furthermore, the interests and needs of the large cities and smaller municipalities are not fully aligned.

According to stakeholders in Basel region, the interest towards new mobility solutions and cooperation has increased significantly. Most stakeholders understand the need for change and the attitudes are in favor for more environmentally friendly alternatives. As a positive result of collaboration, quality of life was mentioned, and the respondents appreciated the promotion of active modes of transport (riding a bike, walking, etc.). One of the positive experiences also mentioned was the fact that stakeholders and companies from different modes of transport want to cooperate, share knowledge and learn together from each other. In Switzerland, even the most significant natural monopoly companies, such as Swiss Federal Railways, have also shown their commitment to knowledge sharing and cooperation.

There are still particular challenges and negative experiences in Basel region also. For example, some influential lobbyist (e.g., automotive associations) are very much focused on sustaining their power and are very conservative regarding new mobility innovations. Also, and maybe typical for Basel region only, there are considerable differences between the development cultures in different countries. Some stakeholders in Basel region are more cautious and slower in adapting and implementing new ideas. For example, attitude towards (organizational) mobility management is not so positive in some of the countries in the region.

Means for motivating stakeholders to participate in MaaS

In the third section of the survey, participants were asked what motivating factors could encourage them to participate in the development and implementation of MaaS offerings. Generally speaking, Finnish stakeholders see more possible factors as motivating than the Swiss stakeholders (Figure 10). This result raises the question if in Finland stakeholder are more motivated and open to being actively involved in MaaS. The only aspects that are considered to be more motivating by Swiss stakeholders are “environmental benefits” (highest share of all items over both countries) and “market-readiness”.
This result supports the earlier argument that Swiss stakeholders are more conservative than the Finnish stakeholders and/or that MaaS is not seen as a separate offering from the well developed public transportation in Switzerland. Generally speaking, essential motivations for stakeholders are compatibility with their strategies, as well as with the existing mobility offers. Besides, economic considerations seem to be important, especially the possibility to gain new customers and being a first mover; however only when the commercial viability is given. This is rather interesting, as the aspect of economic feasibility was not given much consideration in the previous section of the survey. Therefore, it can be concluded that stakeholder viewpoints are not without contradiction and some aspects become relevant only when own interests are on the line.

Another goal of the stakeholder survey was to find out what active roles could the stakeholders imagine for themselves in contributing a MaaS implementation. In our country comparison, the same is valid as for the motivating factors: the share of stakeholders who can imagine a role for themselves in the implementation of a MaaS offering is considerably higher for the Finnish ones. Also, the percentage of “None” is double the size in Switzerland than in Finland (Figure 11).
Figure 11: Share of stakeholders who can consider this role for themselves in MaaS development

However, even in Switzerland, more than 80% of all stakeholders could imagine an active contribution. This result reveals the potential regarding the resources that stakeholders are theoretically willing to provide to the implementation of MaaS - under certain conditions.

The only active role that more Swiss stakeholders could imagine for themselves compared to Finnish counterparts is lobbying. This supports the thesis that Swiss stakeholders are conservative and only prepare for disruptive innovations, yet they do not support it through becoming genuinely active themselves. However, the share of those who can imagine themselves as service providers within a MaaS ecosystem is equal between Switzerland and Finland. A further analysis between stakeholder categories revealed that especially public transport companies could imagine that role in both countries.

Conclusions

The results of our survey reveal that one of the pre-conditions for a successful MaaS implementation seems to be fulfilled already: the general acceptance towards this systemic innovation is very favorable among decision makers and market actors. Also, the questioned stakeholders assume, that MaaS will play a rather important role for future mobility systems. However, there are considerable differences in the stakeholder processes stemming from the cultural and legislative contexts of the regions and the historical development of the collaboration platforms in these two countries.

As an example, PostBus as a subsidiary of the Swiss Post operates in the regional and rural areas of Switzerland and has 869 different routes and 2193 buses making it one of the natural monopolies in Switzerland. Currently, the company is actively developing or acquiring new types of services into its portfolio. In July, the company launched a new smartphone app that combines practically every public transport operator in Switzerland to the same service. Within the application, a customer can use the timetable display to purchase electronic tickets for almost all fare networks, including also mountain railways and cable cars. Later this year, the application will get more features. It will become a country-wide full-featured multi-modal route
planner. In addition to public transport, these will also include taxi services, bicycle and walking routes, private transport and sharing services. Thus, despite very independent cantons in Switzerland, we see public transportation mainly developed under a strong national planning paradigm, with national transportation monopolies setting the pace and more dynamic last-mile solutions serving the regional and local needs. Opinions have been raised that transportation provision could be offered more efficiently in Switzerland and this is mainly because these natural monopolies are not that transparent with the use of their resources. There is also considerable path-dependency in the development of Swiss public transportation, and social innovations have been mainly witnessed inside single Cantons, such as Basel-Stadt.

On the other hand, Finland has chosen to deregulate the industry and rely on new businesses and business models to make transport provision more efficient with increased flexibility and competition. Finnish ministries and regional authorities are making valiant efforts in providing equal opportunities for all the actors and ensuring compatibility of the mobility offers. However, the fast-paced development in Finland has resulted in very fragmented situation (Figure 2) with many of the companies doing overlapping work when trying to serve the mobility needs of the few genuinely urban areas in Finland. The regional actors, such as the Growth Corridor Finland network, are aiming to enhance the vitality of the whole region – not just the urban areas. Currently Growth Corridor Finland is supporting the electrification of the transportation, emphasizing the tools of spatial planning in connecting the rural areas to efficient (and sustainable) transport corridors and creating possibilities for innovative mobility solutions in providing cost-efficient mobility solutions in rural areas also. The effects of this Finnish approach remains to be seen outside these urban islands and on the national level, but interestingly there are already first signs of global scaling of the MaaS business models developed in Finland.

The regional exogenous influences, endogenous political processes, path dependence, the pace of change, and the bounded rationality of the actors are visible in our research. Influential stakeholders tend to be conservative when their interests are challenged or when their interests in the transition are not clear yet. This is the case with automotive associations in Switzerland and national railway company in Finland facing deregulation and the opening of both freight and person transportation on the railway to competition. In contrast, the Federal Railway Company in Switzerland is embracing the change as a part of countrywide service provision, and in other parts of Europe, automotive companies and associations are driving the transition to new mobility services. In our survey, when comparing the results from our two case study areas, stakeholders considered “economic viability” not to be very relevant in terms of innovation support for implementation processes. When asked, however, which factors would motivate themselves to contribute to a MaaS implementation, the respondents stated that economic viability is despite everything a quite important factor for their commitment. This shows that stakeholders’ attitudes are not free from contradictions and this need to be kept in mind when guiding and creating innovation platforms.

The engagement of citizens and stakeholders is one of the critical elements in any regional strategy work. This fundamental duty of local authorities should be enhanced by identifying all the relevant stakeholders and start appropriate, target-group specific, processes to engage them. The importance of this process and the introduction of border-spanning (between regions, authorities, cultures, countries, etc.) innovation platforms is emphasized when dealing with institutional and systemic innovations such as cross-regional MaaS. With our case comparison we hope to inform the existing structures how they can be enhanced in supporting systemic and cross-border innovations – to become real innovation platforms.
References


Mobility-as-a-Service: Development of a Tentative Impact Assessment Framework

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KEYWORDS Mobility-as-a-Service (MaaS); framework; impact; assessment

Introduction

With the continued global trend of urbanization and increased demand for transportation with related issues of emissions, noise, congestion, etc., urban mobility is a major challenge for the future. Many attempts have been made to bring about sustainable changes in individuals’ mode choices and travel behaviours including information and education campaigns to raise commuters’ awareness and change attitudes, competitions and handing out free public transport passes and increasing the attractiveness of public transport via new vehicle designs and improved traveller information. Nevertheless, further efforts are needed in order to solve the problems.

Mobility-as-a-Service (or MaaS) has been argued as a solution to reduce the use of private cars and instead increase the use of public transport and ride sharing services. Few pilots or trials have however been completed (as yet) and even fewer have been evaluated in a systematic and structured way. An assessment framework is essential on order to allow for a more systematic evaluation of impact and comparison between, for instance, different types and levels of integration and/or different business models, a common assessment framework is beneficial.

One of the aims of the project Mobility as a Service for Linking Europe (MAASiFiE) was to develop such a framework and to use the framework for a structured assessment of the possible impacts of (different types of) MaaS. The purpose of this paper is to present the development of the framework as well as the results of the impact assessment in which the framework was applied (see also Karlsson et al., 2017).

Developing the framework

The framework was developed in three main steps: a literature review, a web survey and consensus workshops, before a feasibility evaluation was accomplished.

A number of more or less well-defined impact factors and/or indicators, used in relation to different types of interventions (projects, policies, etc.), were extracted from the literature review. Examples include emissions (e.g., Cascajo, 2005), travel time (e.g. Weisbrod & Weisbrod, 1997b), journey quality (e.g., Kamargianni et al., 2015), modal share (e.g. Burrows et al., 2015) and social inclusion/exclusion (e.g., Burrows et al. 2015). Several of the identified impacts and indicators were considered to be of relevance to more than one main impact area, for instance to environmental as well as social impacts.

The impact and indicators identified in the literature review formed the basis for the design of a web-survey. However, an impact assessment of MaaS was judged to require further focus on the actions of the users...
of the services, as well as the businesses/organisations that provide the services. Additional impact topics were therefore added while less specific ones were excluded (e.g. quality of life). The remaining items were organised according to an individual, organisational/business and societal level respectively. All in all, the survey received 136 respondents from primarily Finland, Sweden, and the U.S. Altogether 57 different types of impact were rated as to their relevance for an assessment of MaaS. Most of the proposed impacts were considered highly relevant by a substantial portion of the web-survey respondents, why the number of impacts needed to be reduced to a feasible number.

The aim of the next step in the development process was to cluster and reduce the number of items. Based on these discussions, and taking the MaaS ecosystem into consideration, the list was reduced to 17 topics or KPIs; six on an individual level, six on a business level, and five on a societal level. They are to different degrees related to the generic impact areas: environmental, economic and social impacts respectively.

**Table 1.** Overview of items on three levels and their connection to environmental, economic and social impacts respectively.

<table>
<thead>
<tr>
<th>Level</th>
<th>KPIs</th>
<th>Environmental impact</th>
<th>Economic impact</th>
<th>Social impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Societal level</td>
<td>Emissions</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resource efficiency (roads, vehicles, land use, ...)</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Citizens accessibility to transport services</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modification of vehicle fleet (electrification, automation)</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Legal and policy modifications</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Organisational/business level</td>
<td>Number of customers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Customer segments (men/women, young/old, ...)</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collaboration/partnerships in value chain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Revenues/turnover</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data sharing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Organisational changes, changes in responsibilities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customer/user level</td>
<td>Total number of trips made</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modal shift (from car to PT, to sharing, to ...)</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of multimodal trips</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Attitudes towards PT, sharing, etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perceived accessibility to transport</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total travel cost per individual/household</td>
<td></td>
<td>√</td>
<td>√</td>
</tr>
</tbody>
</table>

**Using the framework**

As a final step in the process, the tentative framework was tried out. The main aim was to evaluate the feasibility of the framework for assessing the outcome of MaaS. The main cases providing an input included UbiGo in Gothenburg, Sweden (e.g., Sochor et al., 2014; 2015a; 2015b; 2016), and SMILE, in Vienna, Austria (e.g., [http://smile-einfachmobil.at/pilotbetrieb_en.html](http://smile-einfachmobil.at/pilotbetrieb_en.html)). However, a broader basis was desired why an additional sample of primarily MaaS-related services were analysed including carsharing services (e.g., ZipCar, Car2go) and multimodal services (e.g. Kutsuplus, Tuup, and Hannovermobil) (for more detailed
The information used originated from different information sources including project reports and other project documentation, as well as interviews with stakeholders, etc.

As available data did not support a quantitative assessment, a qualitative assessment was made taking into consideration the results of the assessments reflected against additional literature.

Overall, the assessments suggest that a broader introduction of MaaS could result in overall positive impacts, in terms a modal shift, a change in attitudes and an increase in perceived accessibility to the transport system (Table 2). However, some conflicts between impacts on different levels were identified where, for instance increased accessibility to the transport system – a desired impact on an individual and societal level – may result in an increase in the number of trips made – possibly a desired impact on an individual level but an undesired impact on a societal level with negative implications for emissions as well as congestion. When planning for a further introduction of MaaS from a societal perspective, such conflicts must be addressed in order to best determine how to potentially integrate overall societal goals into the MaaS offer and business model.

**Table 2. Overview of anticipated impacts**

<table>
<thead>
<tr>
<th>Level</th>
<th>KPIs</th>
<th>Impact areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Environmental</td>
</tr>
<tr>
<td>Individual</td>
<td>Total number of trips made</td>
<td>√</td>
</tr>
<tr>
<td>/user level</td>
<td>Modal shift (from car to PT, to sharing, to ...)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of multimodal trips (combining different modes of transport)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Attitudes towards PT, sharing, etc.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perceived accessibility to transport</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total travel cost per individual/household</td>
<td></td>
</tr>
<tr>
<td>Business/</td>
<td>Number of customers</td>
<td></td>
</tr>
<tr>
<td>organisational</td>
<td>Customer segments (men/women, young/old, ...)</td>
<td></td>
</tr>
<tr>
<td>level</td>
<td>Level of collaboration/partnerships in value chain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Revenues/turnover</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Level of data sharing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Organisational changes</td>
<td></td>
</tr>
<tr>
<td>Societal level</td>
<td>Emissions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resource efficiency (roads, vehicles, land use, ...)</td>
<td></td>
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<tr>
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</tr>
<tr>
<td></td>
<td>Modification of vehicle fleet (electrification, automation)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Legal and policy modifications</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall positive increase/decrease</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Both positive and negative increase/decrease</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall negative increase/decrease</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Not possible to assess</td>
<td></td>
</tr>
</tbody>
</table>
Reflections

As MaaS is still a new concept, there is a general lack of generally available information on actual impacts of MaaS and the same is true of MaaS-related services. Services which appear to have undergone more thorough evaluations include well-established mobility services, such as carsharing and bicycling schemes, whereas other services, most of which are pilot projects and/or recently introduced services, have not been exposed to the same process (as yet). Furthermore, when evaluations have been undertaken they appear to have focused on those impacts that relate to users’ behaviour in terms of, for example modal shifts and possible consequences on emissions, i.e. on a societal level, whereas impacts on a business level have not been addressed or the information is not generally available. Thus, there appears to be a gap between information needed and topics covered in evaluations (if any), as there is an active search for knowledge in the transportation/MaaS community regarding business and collaboration models, roles and responsibilities of various stakeholders, etc., so as to better understand how to sustainably operationalize the concept of MaaS.

From the limited experience that has been documented, MaaS will result in (or necessitate) impacts on the business level including increased collaboration and partnerships in the value chain, increased data sharing, as well as changes in organisations and their roles. MaaS also has the potential to attract new customer segments, although the impacts on revenues and numbers of customers are unclear due to their intimate link with the specific MaaS offer (number of modes, subscription levels, relative prices, etc.).

A fundamental issue for feasibility studies in general and the assessment of possible impacts which have been part of the present project, is the lack of empirical evidence. The argued impacts of MaaS, positive and/or negative, are to a large extent based on informed assumptions and experts’ opinions. Hence, it is important that different pilots and trials are initiated, with the intention to be developed into a fully functioning service, in order to provide further evidence of the possible impacts of an implementation of MaaS. Resources must then be allocated to address and evaluate different types of impacts (economic, environmental, and social) on different levels (individual, business and societal). However, in order to allow for a comparison between, for instance, different levels of integration and/or different business models, a common assessment framework would be beneficial. The framework introduced in the report provides a first attempt.

Acknowledgements

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The Mobility as a Service (MaaS) sector is expected to grow to a business worth over one trillion euro by 2030. All over Europe, MaaS initiatives are planned or starting up and the MaaS Alliance helps these to cooperate through a shared work programme engaging service providers, transport operators, public authorities and users in order to create a vital and interoperable MaaS ecosystem to fulfil high expectations. To support the development of MaaS, the MaaS Alliance published its guidelines and recommendations to create the foundations for a thriving MaaS ecosystem as its White Paper on 4th of September. The White Paper provides definitions for the main elements of MaaS and identifies some of the main preconditions and the main principles of the ecosystem. The key findings of the White Paper are summarized below.

What is MaaS?

Mobility as a Service (MaaS) is the integration of various forms of transport services into a single mobility service accessible on demand. So MaaS is a service promise, or even more precisely, it is an access promise. For the user, MaaS offers added value through the use of a single application to provide access to mobility, with a single payment channel instead of multiple ticketing and payment operations. To meet a customer’s request, a MaaS operator facilitates a diverse menu of transport options, be they public transport, ride-, car- or bike-sharing, taxi, car rental or lease, or a combination thereof. A successful MaaS service also brings new business models and ways to organise and operate the various transport options, with advantages including access to improved user and demand information and new opportunities to serve unmet demand for transport operators. The aim of MaaS is to be the best value proposition for its users, providing an alternative to the private use of the car that may be as convenient, more sustainable, and even cheaper.

Added value builds on open data and interoperability

Development of the MaaS market will rely on access and openness data, open APIs (Application Programming Interface) and more flexible transport and mobility regulations. When defining regulatory principles for a digitalized transport system, it is imperative to encourage the participation of all market players – both existing and new players - and avoid stifling innovation. IT technologies developed for MaaS should support both commercial-interest-driven and public-service types of MaaS deployment, even though the business models and interests behind them may vary. Open IT architecture and standardised sub-element features, such as payment, ticketing, authentication and security, will be enablers to maximise the development of the MaaS market. In addition to open standards, an imperative requirement is a high quality of the data being exchanged.

User-centric, customer-centric, market-centric

A fundamental principle and core motivation behind deployment of MaaS is that MaaS is a user-centric, customer-centric, market-centric proposition within a societally grounded context. MaaS to become the best value proposition for both private and business users, by helping them meet their mobility needs and solve the inconvenient parts of individual journeys, as well to improve the efficiency of the entire transport system.
Open, inclusive and sustainable

While designing and establishing the MaaS ecosystem, the principles of openness and inclusivity should be fully respected, meaning that the ecosystem should be open to all service providers and inclusive for all different kind of users, including persons with reduced mobility or disabilities. In order to build attractiveness and public acceptance for MaaS services, the whole value chain should be carefully and inclusively designed to meet the high expectations related to ecological and financial sustainability.

The MaaS Alliance

Established at the ITS World Congress in Bordeaux in 2015, following the launch of the MaaS concept at the ITS European Congress in Helsinki in 2014, the MaaS Alliance is a public-private partnership working to establish foundations for a common approach to MaaS, and to unlock the economies of scale needed for successful implementation and uptake of MaaS in Europe and beyond. The main goal of the Alliance is to facilitate a single, open market and full deployment of MaaS services.

There are various stakeholders whose committed participation in the development and implementation of MaaS is crucial to its success. The MaaS Alliance facilitates stakeholder cooperation through a shared work programme engaging all relevant stakeholders, inter alia the following:

- Transport service providers and public transport operators
- MaaS operators and integrators
- IT system providers
- Customers
- Cities, local, regional and national authorities

MaaS Alliance members from all sectors collaborate to create the enablers needed for successful deployment of MaaS in Europe and beyond. The Alliance contributes to European policy-making, promotes the added value of MaaS to local government and business, monitors the MaaS market and facilitates the dialogue with the research community. Finally, the Alliance is the voice of the MaaS community for awareness and advocacy.

Find out more! [https://maas-alliance.eu/](https://maas-alliance.eu/)
SCIENTIFIC 6

Institutional and policy dimensions
A topological approach to Mobility as a Service: A proposed tool for understanding requirements and effects, and for aiding the integration of societal goals

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Abstract

The purpose of this paper is to shed light on the concept of MaaS and what characterizes a ‘MaaS service’, as well as to propose a topology of MaaS as a tool for facilitating the discussion of MaaS, enabling the ‘comparison of’ different services, understanding MaaS’ potential effects, and aiding the integration of societal goals into MaaS services. Based on a literature review analyzing existing definitions, and an expert workshop identifying key aspects and ascertaining service differentiations accordingly, the resulting proposed topology consists of MaaS Levels 0 to 4 as characterized by different types of integration: 0 no integration; 1 integration of information; 2 integration of booking and payment; 3 integration of the service offer, including contracts and responsibilities; 4 integration of societal goals. The levels are described in terms of their added value and further discussed regarding implications for business, society, users, and technical requirements. Then, a deeper discussion also delves into the potential in expanding upon Level 4 and ways by which services and societal goals can become more fully integrated. The proposed topology adds clarity to the discussion of such a trending topic and enables the positioning of services along the MaaS spectrum. It also deepens the understanding of why MaaS can take time to establish, and can help support the development of action plans in terms of what needs to be done depending on what type of MaaS one wants to develop. Further analysis is desirable regarding the possibilities and problems linked with the different levels of MaaS. Such an analysis is key to understanding which effects can be achieved via the implementation of different levels of MaaS services in terms of e.g. social, economic and ecological sustainability, and business potential.

KEYWORDS Mobility as a Service (MaaS), integration, value creation, societal goals, business models
Introduction

Mobility as a Service (MaaS) is often described as an emerging strategy to reorganize transport in order to tackle mobility and sustainability challenges via offering an alternative to private vehicle ownership. It may do so by, for example, combining different types of mobility services as part of a single, seamless offering that is made available to users via subscription-based smartphone applications (Beutel et al., 2014; Goldman and Gorham, 2006; Sochor et al., 2015). However, there is currently little agreement on a ‘definition’ of MaaS, on what makes a service a ‘MaaS service’, or on how to ‘compare’ MaaS services. Additionally, MaaS is also commonly referred to using the rubrics ‘combined’ or ‘integrated’ mobility services, etc. Is MaaS definable, and are these concepts – MaaS, combined mobility, and integrated mobility – the same, or are there differences?

As envisioned, MaaS represents a radical innovation that could potentially revolutionize the transport system, both in terms of passenger and goods transportation. Generally, when radical innovations emerge, there is an initial ‘fluid’ phase that is characterized by experimentation with multiple competing product/service designs (Abernathy and Utterback, 1978). At this stage, uncertainty prevails and the applications of the innovation in question are unclear. Uncertainty is resolved in a later, transitional phase, as the market consolidates to select a dominant design (ibid). The fluidity of MaaS poses at least two problems. First, as the hype grows, and as increasing numbers of practitioners engage with MaaS, questions remain about ‘what MaaS is’. Yet defining the MaaS concept in terms of the content of the service and its applications can be considered, at the present, fluid stage of development, an unwise and premature undertaking. Second, the fluidity of the concept creates challenges in terms of governing a transition to a MaaS-based transport system. If we do not know what MaaS is, how can we know what a MaaS-based transport system can or will deliver in terms of sustainable outcomes? One way to deal with this uncertainty is to develop a characterization of MaaS that embraces the fluidity of the concept.

Hence the purpose of this paper is to develop a topological approach to characterizing the MaaS concept in order to: 1) facilitate more meaningful discussions of the MaaS concept, 2) enable the ‘comparison of’ different services, 3) understand MaaS’ requirements and effects in terms of society, business, users/customers, and technology, and 4) aid in the integration of societal goals. The paper accomplishes this via a literature review and a multi-stakeholder workshop of MaaS experts, resulting in a proposed topology, which is further discussed and analyzed.
**Motivation and Method**

In light of the current discussion of what MaaS is (or is not) and what characterizes a ‘MaaS service’, and after many requests from third parties regarding definitions and classifications, the authors decided to analyze the concepts and services and propose a topology to answer these questions. A topology also provides added value in terms of: adding clarity to the discussion of such a trending topic; being able to promote the concept and position a service within the MaaS spectrum; and, when discussing with decision-makers, being able to explain why MaaS can take time to establish by identifying various barriers and enablers for the different topographical levels, and supporting the development of action plans regarding what needs to be done depending on what type of MaaS one wants to develop.

First, a literature review looked at existing definitions of MaaS and similar concepts in order to identify commonalities and differences (Karlsson, 2016, in Swedish), which is summarized in the next section. Second, a multi-stakeholder workshop was held in order to structure the topology. The workshop took place in November 2016 in Gothenburg, Sweden, with seven experts representing the following MaaS stakeholder types: MaaS operator, transport service provider, researcher, and funder (strategic innovation program). Workshop participants were to: identify relevant aspects of MaaS; analyze existing MaaS or similar services in terms of the identified aspects; and finally, define and describe MaaS levels, as well as place services at the best matching level. Results from both the literature review and the workshop are presented below, cumulating in the proposed MaaS topology and auxiliary discussion.

**Results: Literature Review of Concepts and Definitions (Karlsson, 2016)**

**Combined Mobility (CM)**

Several organizations use the concept of ‘combined mobility’ (e.g. UITP, 2011; Samtrafiken, 2017; Västtrafik in Smith et al., 2017), which tends to focus on combining modes in general, perhaps with the facilitation of planners, purchasing functions, etc. The definitions of CM are typically broad – along the lines of ‘smart services, from planning to purchasing’ which may complement public transport (PT) or which may entail not needing to own a private car – leaving open what such services can entail, and thus lacking guidance as to how to achieve such services, e.g. how to combine modes.

**Mobility as a Service (MaaS)**

The MaaS concept tends to focus on the (aspects of the) service and not the modes, and sometimes brings in the term ‘integration’ (e.g. Hietanen, 2014; Kamargianni, 2015; König, et al., 2016; MaaS Alliance, 2017; Trafikverket, 2016; Transport Systems Catapult, 2016). Many well-established phenomena, e.g. carsharing and taxis, can be described in terms of mobility services, but definitions of the ‘new’ MaaS concept also include other significant elements, such as customers’ needs, personalized/tailored and comprehensive solutions, an interface, a mobility platform, integrated payment, a contract, a service offer, a business model, a service provider, etc. The aspects of goods transport (MaaS Alliance, 2017) and sustainability (MAASiFiE project, König et al., 2016) do appear, albeit rarely.
Integrated Mobility Services (IMS)

The concept of Integrated Mobility Services (IMS) is often used in limited reference to integrated information services, i.e. services that integrate information about different modes and from different service providers. This is in a way unfortunate, as this concept could potentially best capture the central elements of these ‘new’ mobility concepts (cf. the previous section on MaaS). Broader definitions of IMS (e.g. K2, 2017; Mukthar-Landgren et al., 2016) tend to emphasize integration of various services in terms of e.g. multimodality, information, payment, and even other related services (deliveries, repairs) via a single/common interface.

Conclusions from the literature review

There is currently no established definition of MaaS (or CM or IMS), and, as discussed above, it is likely premature to provide ‘one definition’ at this early stage of MaaS development. Different descriptions and definitions highlight some common and some different central elements, although, no matter the term, it is about:

- Offering a service with customer/user/traveler transport needs as the main focus;
- Offering mobility rather than transport;
- Offering integration of transport services, information, payment and ticketing.

In terms of integration, there needs to be a clearer characterization of different types of integrated services. The challenges faced in the development of integrated services are at least partially related to which types of service elements are to be integrated and to which degree. Despite this, and although various analyses have explored barriers of MaaS (e.g. Holmberg et al., 2015; Mukthar-Landgren, 2016; Sochor et al., 2016a; Transport Systems Catapult, 2016), there is not yet any thorough analysis of the connections between the different types of integrated services and the services’ challenges and potentials. Integration can, for example, comprise:

- Integrated information services / multimodal travel information. This, together with integrated payment services, can be considered MaaS’ ‘core’;
- Integrated booking or ticketing, e.g. a ‘smartcard’ or a mobile app that can provide access to different modes;
- Integrated payment or invoicing;
- Organizational integration. Collaboration between different transport providers (car- and bikesharing, taxi, bus, train, etc.) is a prerequisite for integrated mobility, but how that collaboration occurs will differ between MaaS services.
- Bundling, which entails e.g. a subscription to trips with different modes. This type of integration has so far been the exception rather than the norm, but this may change in the future. Analyses of the success factors of the UbiGo pilot in terms of both customer satisfaction and behavioral change showed the importance of developing the service and its offer to the customers (Sochor et al., 2016b).
Results: Workshop and the Development of the Proposed Topology

During the workshop, aspects of different perspectives – societal, business, user/customer, and technical – were first identified and discussed, and then collectively narrowed down to a limited number of key aspects (underlined below) in terms of both overall importance and differentiation in service levels (i.e. how do different services differ from each other). Due to time constraints, the workshop did not further delve into more specific stakeholder perspectives, e.g. employers, tourism, housing.

From the societal (or policy) perspective, the aspects considered most relevant were the effect on: private car ownership (current and potential), private car use (congestion and emissions), use of resources (materials, energy, etc.) and existing infrastructure, sustainable accessibility, urban planning and, in the long term, a city’s attractiveness and livability, management of traffic and mobility, attitudes and awareness, equitable access (social and geographical), innovation, employment, and, in the future, automated vehicles.

For business, the following were considered important: new customers (number and type, i.e. new markets), new business models, bundling and pricing, becoming a market player, reduced costs (e.g. recruitment, support, management), integration costs, changes in mode use, influencing use, exclusivity (competitively neutral), the customer relationship and ‘owning’ the customer, branding, contracts, burden of responsibility, liability and guarantees. Certain aspects may be more or less important if the MaaS service is a ‘brokerage’ versus a mobility marketplace.

From the user/customer perspective, identified important aspects included: how well the service meets one’s entire mobility needs (including accessibility and door-to-door solutions), what transport services are included and where they are located (breadth of service), bundling/packaging, flexibility (easy to modify, minimal lock-in effects, etc.), low-risk trialability, cost and price worthiness, burden of responsibility, liability and guarantees, customer support, personalization and customization, decision support (e.g. travel planning), ticketing and payment solutions (easy to book/modify/authenticate and pay), usability (both the interface and how easy it is to understand the offer, pricing, etc.), and data security and protection (ownership, sharing, etc.). For B2B, even easy administration and improved accessibility for employees, customers and visitors.

From the technical perspective, the following were identified as relevant: information/planning function at different levels (a) ‘only’ centralized information, b) multimodal travel planner, and c) assistant i.e. taking one’s schedule into account), payment solutions, APIs, platforms (both front- and back-end solutions), data analysis, integration with existing systems, and user interface.

Next in the workshop, participants identified examples of MaaS or similar services, and, to the best of their knowledge about specific services, attempted to break down how the services differed based on the above, identified key aspects (underlined); see Figure 1. Among existing services were identified: travel planners (with or without real-time information), travel planners with ticketing and payment functions (e.g. Moovit), travel planners with booking and payment functions (e.g. SMILE), mobility marketplaces (e.g. in the Netherlands), ‘public transport plus’ (e.g. Hannover Mobil), and ‘MaaS operators’ (e.g. UbiGo, Whim/MaaS Global). For comparative purposes, a unimodal service (Uber) was included.

Regarding Figure 1. This figure is mainly based on the perspectives of the customer, provider and business, as, if a service does not deliver value to the customer or provider, and if the value cannot be captured by the business, then the service is not particularly relevant or sustainable. Regarding the two, isolated ‘x’ marks for Hannover Mobil and SMILE under ‘pricing models a) rebates’, rebates alone do necessitate some type of
collaboration above and beyond commissions, but they are perhaps not enough to qualify as a pricing model and could potentially be moved to a special case of payment integration. Also, note that the top row (policy) lacks ‘x’ marks, an area of particular relevance for public actors to work within. How does one create the right conditions for mobility services to achieve the desired effects? This is where integration of public transport modes will be highly relevant, as these contracts can contain more than the usual commercial conditions.

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<th>Moovit</th>
<th>Hann. Mobil</th>
<th>Smile</th>
<th>Moovel</th>
<th>Whim/ UbiGo</th>
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* Uber, a unimodal service, is included for comparative purposes.

In Figure 1, one can make some differentiations (illustrated by colored clusters in the figure) based on contracts, sharing of risk, responsibility to the customer, and to what degree a service is perceived as a ‘unified’ service versus a combination of services. From this differentiation, one way to develop a relatively simple topology for MaaS is to start with the clusters as different levels of integration (see Figure 2) and then add layers of nuance e.g. number of modes (n=4), information functionalities (b=travel planner), etc.

Figure 2 presents the proposed MaaS topology with Levels 0-4 describing varying levels of integration (further discussed below): 0 no integration; 1 integration of information; 2 integration of booking and payment; 3 integration of the service offer, including contracts and responsibilities; 4 integration of societal goals. Before the discussion of the levels, note that one level is not necessarily ‘better’ than another, as it depends on the customer and his or her needs. However, potential societal effects and business potential are related to the levels, as is which type(s) of actors may run the service. Second, the levels are not necessarily dependent on each other (e.g. the UbiGo pilot was a Level 3 service that more or less lacked Level 1 functionality outside of pricing information). As for matching services to levels, there are always issues of interpretation; e.g. does one classify multimodal public transport with a travel planner and some degree of integrated ticketing/payment, e.g. Västrafik in Gothenburg, as Level 0 or as Level 2?
Explanation and discussion of MaaS topology levels

Level 1

This level represents integration of information, which can be further classified by functionality, as in Figure 1 above, according to a) ‘only’ centralized information, b) multimodal travel planner, and c) assistant. The added value of Level 1 is decision support for finding the best trip. It has a single trip focus and has users rather than customers. Today, most travel planners or other types of mobility information sites or apps are financed by ads or taxpayers’ money. The end users are typically not prepared to pay for travel information, targeted or not, no matter the perceived value.

Transport service providers contribute by supplying open, standardized data for free, which is the case for many public transport agencies. The market will most likely be controlled by a few global players with user bases large enough to attract advertisers, e.g., Google, but there is a clear niche for local, publically operated travel planners and traffic information sites. With a large online user base, the information that global actors collect can be sold to cities for traffic management or infrastructure planning, which is an already established revenue source for such actors. It will however be hard for small companies to keep up, as users more and more will expect ‘smart’ travel assistants that integrate both personal planning information and relevant data from a broad spectrum of sources. The aggregated information can also consist of price and reservation information and, by forwarding a user to the chosen provider, an ‘information market platform operator’ has the chance to get a small commission. A Level 1 operator will not be responsible for the quality of the service about which it provides information, and in a legal sense not for the information itself. However, users will turn away if they find (or perceive) that the information cannot be trusted or is hard to understand.
Level 2

This level represents integration of booking and payment. A Level 2 service focuses on single trips and could be a natural extension to a travel planner, adding public transport ticketing, taxi, or other transport services where possible. In fact, a booking and payment service needs to tie in to a travel planner or some other information service to identify options. Level 2 is sometimes referred to as a bottom-up approach (Architura, 2017).

The added value of Level 2 is to offer users easier access to services, i.e. a one-stop shop where the user can find, book, and pay with the same app (e.g. with a preregistered payment card), and for the transport service providers to be exposed to more customers. This level can be used by registered and/or ad hoc customers depending on the mode (e.g. carsharing requires registration), or perhaps by third parties such as a brokerage. A Level 2 service will make travel easier for those who are already multi/intermodal, but the offer is probably not comprehensive enough to make households to sell their first or second car and, in that way, create new customers.

Although transport service providers gain a cost-effective exposure to the user base, since they will be offered side by side with competitors, the value will be highest for new, small, or niched services that can win market shares. It is possible that some of the more established suppliers will be less interested in being part of a ‘mobility bazaar’, especially if it comes with a cost, but this of course depends on how dominant the service is. The cost and complexity of integrating many suppliers can be high, depending on the level of standardization. More suppliers also means more contracts. If the service/platform is operated by a public entity, e.g. a public transport authority, it will likely need to be open to all suppliers or be subjected to a quite complicated procurement process.

The Level 2 operator takes responsibility for valid tickets, accurate bookings, and the purchase, but not for the actual travel services. The revenue will come from brokering fees, commissions, and/or from fixed supplier memberships. It is unlikely that users will be willing to pay extra for the assistance in buying a trip if is not combined with some extra service. Despite the low margin, users may expect the operator to take responsibility for the services they in fact have bought from the operator (even when supplied by a provider), thus a Level 2 operator may need to offer first-line support. Low margins, high cost of integrating many services, and cost of first-line support can make it hard to run a Level 2 service – as a separate business, that is. It could however add value to an already existing, non-mobility-based business. If hotels, event companies, shopping malls, etc. could integrate transport into their offer to their customers, the perceived value of their service may be much higher than the cost of integration. One service to include in tickets, campaigns, and other travel or rental services is public transport. In that case commission is not really of any importance, which means that there may be a niche for a B2B aggregator; a clearinghouse that offers easy access to multiple transport services for businesses. It would be like Amadeus for air travel, but with much smaller transactions, and many more and local suppliers, often with different price models. Like an information service with a large user base, aggregated data on users’ behavior may perhaps be sold to cities for traffic and mobility management. In addition, an integrated service involving economic transactions can also be used to mediate incentives for choosing more sustainable modes of transport, changing travel times to off-peak hours, etc.
Level 3

This level represents integration of the service offer, including contracts and responsibilities. The added value of Level 3 is the comprehensive alternative to car ownership, with a focus on the customer’s complete mobility needs, and the transport service providers’ increased attractiveness to customers they cannot reach as single services. The Level 3 service is bundled, possibly subscription-based, and there is full, two-way responsibility from end user to supplier and vice versa. It is most likely financed by the bottom-line difference between the repackaged services and the volume agreements with the transport service providers.

A Level 3 MaaS service typically focuses on the total need of a household – it is about getting from morning to evening, Monday to Sunday, and spring to winter, rather than single trips from A to B. It is positioned towards offering a comprehensive alternative to car ownership in order to attract customers with larger mobility budgets and willingness to pay for quality and ease of use. It involves a mutual commitment, at least on a monthly basis. As the service is bundled in some way, MaaS should, in this case, be read as Mobility as A (unified) Service. Level 3 is also referred as a top-down approach (Architura, 2017).

As the MaaS operator takes responsibility for the service delivered to its customers – and for its customers towards the suppliers – it is more than a broker or an open marketplace. The MaaS operator typically works more closely with one preferred supplier per mode in order to also create value for the suppliers and, with that, better deals for its customers. For example, running a carsharing operation is a tight business; if the cars at a site are used too little, they generate a loss, but if the usage is too high, the users will complain and the company will need to add a car (that may be used too little). If the MaaS operator can grow the total customer base and increase the overall usage of the shared cars, this could mean the difference between profit and loss.

The MaaS operator’s business is based on a ‘swings and roundabouts’ principle, i.e. some trips or modes are resold with high margins and some at a loss. The pricing is non-transparent – what the customer pays to the MaaS operator is not directly linked to what the operator pays to the supplier, and the price models can be different from what the suppliers themselves market to their own customers. It is much like an all-inclusive charter trip as opposed to the travel agency approach in Level 2, as the traveler does not know the cost for the separate items (flight, hotel, dinner, tours, etc.). For an operator that is skilled in negotiation and understanding customer needs, this opens up for a higher average margin. The bundled service could also be offered to companies as mobility packages to employees.

In a Level 3 service, an ICT-platform is needed to run the business, but in a Level 2 service, the platform is the business. Interestingly, the complexity of the technical integration can be lower for a Level 3 service than for a Level 2 service due to fewer suppliers and less interaction. A Level 1 information service could be more or less a common, global business, as long as there exists some standardized open data. A Level 2 service needs local presence due to more interactions and business agreements with regional or local suppliers. A Level 3 service is local – it needs to find the best supplier of each mode with whom to develop the service, and it needs to find politically acceptable contract models with the regional or local public transport authorities. However, the platform can be shared among networked operators, also opening up for roaming, where customers in one local service can use their native mobility subscription when visiting other cities.
Level 4

This level represents integration of societal goals. The added value is reduced private car ownership and use, a more accessible, livable city, etc. Incentives are implemented in the MaaS service (or implemented in individual services, as a Level 4 approach could be integrated at any level), reflected by e.g. how well local, regional, and/or national policies and goals are integrated into the service.

The public authorities on a city, regional or national level can influence the societal and ecological impacts of mobility services, i.e. influencing users’ behavior by setting conditions for the operators so that they will create incentives for desired behavior. This applies to both individual transport service providers and MaaS operators. Two important public actors are cities that dictate the use of infrastructure and public space, and public transport agencies that often control the ‘backbone’ of mobility. In the long run, cooperation with these actors is a ‘must-have’ for potential MaaS operators and the transport service providers. For public actors, their monopoly position should be used to make sure mobility solutions not only fulfill citizens’ needs, but the city’s goals as well. For instance, a public transport agency can set a hard, but wide framework for the reselling and repackaging of public transport. A city can also use dynamic road charging in dense areas, something that will be crucial if cheap, self-driving taxis start to win over public transport users. A MaaS operator may need to share non-sensitive user data for city or traffic planning purposes, reach a certain conversion rate, or forward incentives such as benefits for shifting to off-peak public transport trips.

Mixing public, often subsidized, services with commercial services into customizable packages poses different challenges. Public transport is a one-size-fits-all service with non-flexible price models, while an attractive MaaS offer needs to be perceived as a unified, flexible service. It is the public transport service that needs to be integrated rather than the existing public transport ‘products’ such as single tickets or monthly cards. To be politically acceptable, resellers need to prove that the pricing of public transport, as part of a MaaS service, is revenue, tax, and price neutral compared to the direct sales of tickets. A MaaS service run by a public transport agency will experience the same problem – if the service should be attractive enough to compete with car ownership.

It is also important to understand that a business model is connected to the organization that owns it. The possible offers, revenue streams, relationships, partnerships, and agility all depend on who runs the service, as do the effects on the transport system. Will MaaS make it easier for public transport users to use a car or for car owners to use more public transport? Level 4 is really about how to balance the demands on transport service providers and MaaS operators against the possibilities to run a ‘profitable enough’ business. This means developing contractual models for private-public cooperation, and understanding how changes in a policy framework will affect users’ behavior with transport service providers and MaaS operators as intermediaries.

Achieving a transition to a MaaS-based transport system

MaaS has the potential to revolutionize the way we travel. The proposed transformation is radical in scope, and may be described using the notion of a socio-technical transition. The latter is defined as “...a gradual, continuous process of change where the structural character of a society (or a complex sub-system of society) transforms” (Rotmans et al., 2001). A transition to MaaS may be considered sustainable if MaaS contributes to the fulfilment of societal goals, such as the need for decarbonization of the transport system, reduced congestion, innovation, and better accessibility. In other words, a transition to MaaS services that integrate
societal goals (Level 4) may be considered sustainable. In this section, we address the question of how a transition may be governed, such that barriers and obstacles to change are overcome, by referring to the field of transition management. The latter outlines four activities that are key to the governance of sustainable transitions: strategic, tactical, operational, and reflexive activities (Kemp and Loorbach, 2007; Loorbach, 2007, 2010).

- **Strategic** activities are collaborative, multi-stakeholder processes, which aim to ensure that long-term visions (i.e. societal goals) are shared and embedded among collectives.
- By contrast, **tactical** activities serve to link individual actor strategies to the shared long-term visions created via strategic activities, aiming to overcome short-termism within different societal sectors (e.g. politics, business). They also aim to tackle the difficulties in implementing solutions by acknowledging complex sources of inertia within regimes, and directing activities such as corporate political action and lobbying towards the reformation of such structures.
- **Operational** activities aim to link everyday activities such as innovative experiments to long-term visions, broader policies and change agendas.
- **Reflexive** activities include the ongoing monitoring, assessment and evaluation of policies and practices as a means to revise overarching visions and plans where necessary.

The current ‘fluid’ phase of MaaS development, which is characterized by experimentation with multiple competing product/service designs (Abernathy and Utterback, 1978), we argue that operational, tactical, and reflexive activities are presently the primary focus for MaaS practitioners (and other stakeholders) at Level 4. Generally, operational activities aim to link everyday practices (e.g. innovative experiments conducted by MaaS practitioners) to broader visions and change agendas. Here the term ‘vision’ refers to relevant societal goals, including transport policy objectives (decarbonization, reduced congestion, improved accessibility, innovation, etc.) or other societal trends such as digitalization and the shift to a more circular economy. By contrast, tactical activities: link individual actor strategies to shared long-term visions; aim to tackle the difficulties in overcoming institutional barriers to change; and lobby for and experiment with new institutional arrangements. The overarching point is that the capacity for MaaS to support transport policy objectives and other societal goals is essential to its success. Operational, tactical, and reflexive activities are all needed to demonstrate this potential, and require engagements from MaaS practitioners within the public and private sectors.

In terms of operational and reflexive activities, there are several things MaaS practitioners can do to link innovative experiments to broader visions and political goals. One example is to demonstrate how MaaS services (including pilots) contribute to reduced congestion and emissions, improved accessibility, and sustainable travel behavior of users. A further example, as noted in previous sections, is to show how non-sensitive user data generated via MaaS can be sold to cities for traffic management purposes to improve the sustainability of the transport system. In future, developments in connected vehicles and other digital technologies could allow for real-time traffic management of ‘smart’ cities, allowing for further sustainability gains. Demonstrating the benefits of experiments such as these can help to garner financial and political support for a transition to a MaaS-based transport system. Operational and reflexive activities may focus on other types of innovative experiments for the same purpose, including: the further integration of transport modes within MaaS business models; the scaling of MaaS business models to new geographical areas; roaming; the integration of incentives for sustainable travel behavior into MaaS services (i.e. incentives such as nudging and gameification to promote shared mobility and sustainable modal choices); the further introduction of environmentally benign technology into vehicle fleets (e.g. electric drives) as a means to
reduce transport emissions; and so on. Operational activities ensure that experiments and innovations are directed towards the resolution of societal problems, and reflexive activities evaluate and assess the way in which MaaS generates sustainable value for different societal stakeholders.

In terms of tactical activities, transition management involves making it clear how the strategies of individual MaaS practitioners can collectively contribute to the sustainable development of the transport system. Similar to operational activities, linking individual strategies in the private and public sectors to broader visions provides MaaS with credibility and legitimacy among societal stakeholders, and can help to garner financial and political support. In practice, this means that MaaS practitioners should establish organizational strategies, goals and targets that collectively aim to improve the sustainability of the transport system (e.g. by attracting X numbers of new users, our company aims to reduce transport system emissions in city Y by Z% in five years).

MaaS practitioners can engage in a further type of tactical activity, which is to engage a set of key stakeholders with the mandate to provide the types of support necessary to allow MaaS to flourish. In practice, these actors may be financial investors, who are willing to provide capital to support successful business models; civil society organizations that can champion MaaS by shaping public opinion; and public authorities, who are willing to create a set of supportive institutional arrangements given the demonstrated sustainability benefits of MaaS. Examples of such institutional arrangements include the revision of fiscal policies and the redistribution of subsidies on a municipal, regional, or national level. Public authorities can also influence the social and ecological impacts of mobility services by placing demands on operators to create incentives for desirable travel behavior; and they can support the diffusion of MaaS by providing exemptions from congestion charges, altering parking regulations, allowing shared cars to travel in bus lanes, etc. Further, public authorities can integrate MaaS into local transport policy objectives by, for example, using dynamic road charging in dense areas.

In practice, mixing public, commonly subsidized, services with commercial services into customizable packages poses significant challenges. Public transport is a one-size-fits-all service with inflexible price models, whereas an attractive MaaS offer is designed as a unified, flexible service, which may be commercially driven. To gain acceptance, MaaS practitioners must demonstrate to one another that their business strategies and practices will not encroach on others’ customer base and brand. Also, (particularly commercial) MaaS operators must ensure that public transport is priced at a revenue-, tax- and price-neutral level compared to the direct sales of tickets. In order to overcome these types of barriers to collaboration, it may be necessary to engage third-party actors (possibly public authorities) that can act as neutral gatekeepers to help overcome existing levels of fragmentation between and protectionism/risk aversion among MaaS practitioners. Fragmentation is not limited to MaaS practitioners: cities have large role to play in that they dictate the use of infrastructure and public space; and public authorities commonly control the ‘backbone’ of mobility. Private sector engagement is also needed to unlock the innovative potential of MaaS, which spans the transport, telecom and energy industries (Spickermann, et al. 2014). In situations where existing stakeholders and practitioners cannot overcome the types barriers described above, relevant third parties may need to step in as neutral orchestrators of collaboration. To summarize, engaging different types of stakeholders is critical for two reasons: 1) it can provide a platform for MaaS practitioners to lobby for and experiment with new institutional arrangements; and 2) it can aim to tackle the difficulties in overcoming institutional barriers to the development and diffusion of MaaS.
Concluding remarks

There are currently many examples of different mobility services, from multimodal travel information (including park&ride, parking, etc.) to integrated ticketing services, to ‘MaaS operator’-type services. However, lumping all these services together under one loosely defined concept such as MaaS creates confusion and potentially undermines the concept as it can then be perceived as merely the latest buzzword; a new name for the same old thing. As illustrated and explained above, not all services are ‘equal’ in the MaaS topology. The innovation in MaaS, but also the challenge, likely lies not only in the integration entailed in the levels above, but the organizational integration (not least between public and private actors) and the bundling required to achieve Levels 3 and 4. Understanding the MaaS topology and its implications can help nuance the conversation, deepen the understanding of barriers and enablers for different levels, and facilitate the development of MaaS, e.g. in the form of action plans tailored to the intended MaaS level and goals.

Regarding the topology per se, it could be argued that it may be too ‘simplistic’, as there may exist hybrids between levels, and as pointed out above regarding matching services to levels, there are always issues of interpretation; e.g. does one classify multimodal public transport with a travel planner and some degree of integrated ticketing/payment, e.g. Västrafik in Gothenburg, as Level 0 or as Level 2?. There may also exist additional aspects that have not been applied to the levels, e.g. geographical context (urban, suburban, and rural MaaS); and Level 4 could potentially be broken down into the three types of sustainability – social, economic, and ecological – and applied in a third-dimensional layer across all levels, including trade-offs between types of sustainability, e.g. accessibility/social and ecological. However, the purpose of developing this topology was not to present an exhaustive and static description of MaaS, but rather to provide a straightforward and dynamic tool as a basis for discussing, understanding, and comparing different types of services, their viability and effects. In other words, we posit that the topology may be a useful fundament for a set of tactical, operational and reflexive activities that can assist in a transition towards a sustainable, MaaS-based transport system.

As a next step in deepening the understanding of MaaS, further analysis is desirable regarding the possibilities and problems linked with the different levels of MaaS, preferably based on thoroughly evaluated case studies, more of which are needed (Karlsson et al., 2017). Such an analysis is key to evaluating and understanding which impacts and effects can be achieved via the implementation of different levels of MaaS services in terms of e.g. social, economic and ecological sustainability, as well as business potential. That is, there is a strong need for reflexive activities that assess and evaluate the utilities of MaaS as an operational phenomenon.

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Institutional and policy hindrances for urban car sharing: examples from the UK, Israel, Finland and Sweden

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Extended abstract:

The rapid growth of cities requires effective management of transport demand and restructuring of transport systems to address the needs of growing urban populations in a sustainable way. In recent years, car sharing has emerged as an alternative to owning cars in city centres, which has potential to bring environmental gains and address social considerations. A commercial car sharing scheme is defined as short-term usage of cars, provided by a private operator, whereby users pay a registration fee and usage fee that is dependent on the time used or the distance travelled. There is sizeable academic inquiry about the social and environmental benefits of car sharing and the barriers to its uptake and provision in different empirical contexts. However, most research on the determinants of its uptake and the ease of provision remains limited to investigating consumer demand and how to realise the benefits of car sharing.

Drawing on the cases of the UK, Israel, Sweden and Finland, and using interviews, analysis of relevant policy documents as well as local knowledge, we aim to explore policy setting and systemic barriers for commercial car sharing services.

The main insights from the cases have been grouped into four themes. First, the role of local institutional and policy contexts play a large role in the evolution and support of these schemes. The main policy implication is that the number of actors and the institutional settings that affect lobbying of the car sharing market play an important role in the provision of the services. Second, the issues affecting the role of public transport on the provision of car sharing services have several dimensions. The two main ones are the financial support to integrating car sharing services into current public transport networks and the different policy perception of car sharing which results in various challenges for such integration. We conclude that it is important to have clear understanding of what car sharing services are and their role in their respective transport systems and that car sharing must be recognised as unique mode of transport, likely with some case-specific characteristics that can be aligned and adapted to fit in with more general transport policy priorities and objectives, mainly at the regional/metropolitan level. Third, we discussed the similarities and the contrasts between the user profiles in the different cases. One of the main policy implications of this key comparison is that there is a geographical aspect to identifying the target user groups and that density of cities plays a crucial role. It is important for car sharing schemes to focus on areas, which are not easily accessible by public transport, yet from a business (profitability) perspective it makes no sense to focus on these areas. This gap between commercial and public (transport) considerations must be fully recognised by transport authorities, which cannot expect the ‘market’ to go to these areas, even if parking is given for free. Fourth, parking was highlighted time and again across the case studies as the linchpin to the set up of schemes. Pressure for parking space was a common issue, but the key determinant as to whether this would render car sharing unworkable related to institutional responsibility for parking policy.
Like any other (transport) policy, car sharing is not a silver bullet to solve cities’ transport problems, but if it is a strategic policy measure in a ‘policy package’ it can make a large contribution towards moving to low carbon mobility. It is currently seen more as a useful innovation that has a large potential, but has not been given enough attention to facilitate and ensure this potential is realized, especially outside city centres. What these case studies have highlighted is that there are significant institutional considerations that need to be addressed in order for car sharing to achieve its potential. Understanding the governance requirements of car sharing schemes necessitates identifying its role in relation to and integration with public transport systems. This in turn raises further policymaking issues for car sharing schemes.

**KEYWORDS** car sharing; urban governance; institutions; public transport
Understanding institutional enablers and barriers to the dissemination of MaaS: A tentative framework

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KEYWORDS Mobility-as-a-Service; framework; institutions; barriers

1. Introduction

With a continued global urbanisation trend and increasing demand for transportation with consequences in terms of, for example, congestion, emissions, and noise, urban mobility is a major challenge for the future. Mobility-as-a-Service (MaaS) has been argued as part of the solution by contributing to reducing the use of private cars and increasing the use of public transport and ride sharing services: “MaaS has the potential to fundamentally change the behaviour of people in and beyond cities, hence it is regarded as the biggest paradigm change in transport since affordable cars came into the market” (maas-alliance.eu). However, even though a number of initiatives have been taken, including pilots which have shown positive outcomes (see e.g., Karlsson et al., 2016), the implementation of MaaS has been slow.

Different sources refer to different challenges. The purpose of the project ‘Institutional Frameworks for Integrated Mobility Services in Future Cities’ (IRIMS) is to determine how, and to what extent, existing institutional factors affect the further development of MaaS. The project aims to provide suggestions for how institutions can be modified to enable the implementation of MaaS to contribute to sustainable mobility. This paper presents part of the work: a tentative framework, intended to support the analysis of the institutional factors that facilitate or create barriers to the further development and dissemination of MaaS (see also Mukhtar-Landgren et al., 2016).

2. Theoretical basis

The framework draws upon institutional theory. Institutions can be understood as “… a relatively stable collection of rules and practices, embedded in structures of resources that make action possible” (March and Olsen, 1989). Scott (2014) suggested that institutions comprise “… regulative, normative, and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life” (p. 56). Regulative refers in this case to rules and sanctioning activities that are formal and explicit; normative elements include values and norms; and cognitive aspects are those categories and conceptualisations through which identities and meanings are constantly interpreted and re-interpreted (Thornton et al., 2012; Scott, 2014). Institutional obstacles and opportunities are thus not restricted to formal aspects but also informal aspects must be taken into consideration, including for example perceived roles, daily habits and practices (March and Olsen, 2006; Niemann, 2013).
3. The framework

3.1. Accomplishment

The development of the framework is based on the following key activities:

- literature reviews (see also Lund et al., 2017);
- a series of workshops with project partners who represent different competencies and experience; and
- interviews with stakeholders (public as well as private, entrepreneurs as well as customers) who have been or who are presently involved in the development of MaaS services (in Finland, Germany and Sweden) (see also Smith et al., 2017a; 2017b).

3.2. A three levels model

The proposed framework is based on the notion of institutions. Regulative aspects are here referred to as formal features while normative and cognitive features are described as informal features embedded in the institutions. The institutions are then related to three different levels: macro, meso, and micro.

3.2.1. Macro level

The macro level includes broader social and political factors, including both formal rules and more informal social norms and perceptions.

A frequently mentioned macro level issue concerns who can sell (subsidised) public transport tickets and who cannot. Taxation is another key factor where current models is considered a possible barrier as these rules have not (yet) accommodated to the ideas of a sharing economy.

Referring to more informal aspects, Lund et al. (2017) argue that many policy makers consider MaaS to be an important part of the solution to present transport related problems but that there are also those who are concerned that MaaS will create increased access to transport services and hence result in an increase in the number of trips made. This concern may create a barrier for policy makers to support the development of MaaS.

3.2.2. Meso level

The meso level refers to organisations (private, public, private/public hybrids as well as non-profit organisations) and communities, including collaborative networks. The formal dimension here includes policies and regulations that are implemented on a regional and local level. An example is legislation that hinders carsharing stations to use public space for parking; easy access to carsharing being an important part (and enabler) of MaaS (cf. König et al., 2016).

The informal dimension includes, for example the way collaboration and partnerships are established among actors that have not previously worked together. Each actor enters the collaborative processes that signify MaaS with their own ideals, interests and expectations. An important challenge for creating MaaS and for the creation of a competitive service content is, indeed, collaboration between different actors (Holmberg et al., 2016) but cooperation between, for example public and private service providers is not well established (König et al., 2016).
A major issue is to what extent key actors believe that MaaS provides a business opportunity. Public as well as private actors express a fear of losing customers to other service providers, of losing one’s own brand image as well as one’s relation to the customers (e.g. Smith et al., 2017a; Sochor et al., 2015). Even though there is an opportunity to attract new categories of customers, several sources (e.g. Karlsson et al., 2017) argue that there is as yet little knowledge on travellers’ actual willingness and intention to adopt MaaS, an uncertainty which hinders the actors taking “the next step” (Smith et al., forthcoming).

A related obstacle is the perceived lack of appropriate business models. Although various models have been proposed in which different actors take on different roles (see e.g., König et al. 2016), both private and public actors express uncertainty as to what their respective roles could, or should, be within a MaaS. In particular this concerns public transport organisations.

3.2.3. Micro level

The micro level can describe the individual as citizen, as tax payer, but here the micro level refers primarily to the individual as customer and user of MaaS. This is the least investigated level of the three.

The identified formal barriers and enablers on a micro level are mainly consequences of laws, regulations, and policies implemented on the meso and macro levels, such as for example congestion tax.

The informal factors include norm, values, and habits (e.g. Verplanken et al., 1998). Whereas the private car is often described as “the norm” several investigations now indicate a change, not least among the younger generation. Furthermore, societal trends in terms of environmental concern and the notion of a sharing economy, open up opportunities for services such as MaaS (e.g., König et al., 2016).

Other barriers to the adoption of MaaS have been found to include economic aspects but also perceived efforts associated with having to learn how to use a new service (Sochor et al., 2016), i.e. creating new habits and routines. Travel patterns are habitual why changes in travel behaviour are not likely to occur unless MaaS fulfils the customers'/users’ travel needs in a way that is salient and have positive outcomes (cf. Gärling and Fuji, 2009). Pilot trials of MaaS have shown that these new services can provide several perceived benefits, such as convenience, flexibility, and perceived increased access to mobility options (Karlsson et al., 2016) even though not for all.

4. Concluding remarks

The IRIMS project has created a framework based on institutional theory and has identified institutional factors of importance though literature studies, workshops involving actors with different expertise and experience, and by interviewing actors who have been or are presently involved in the development of MaaS.

The described framework is tentative and need further development. For example, even though not developed here, there are evidently considerable interdependencies between the levels and between formal and informal aspects. These interdependencies need to be further investigated. There is also a need to further look into the differences between different stages of MaaS development: initiation, implementation, and regular operation to understand the factors that contribute or create barriers to the dissemination of MaaS. Fundamentally, empirical evidence is (as yet) to a large extent lacking but is needed in order to understand, in-depth, the factors that influence the development of MaaS in different contexts.
Acknowledgements

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MaaS in cities
Consideration of co-creation autonomous distributed system for MaaS

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Abstract

We propose a system that can collaborate highly even among distributed DBs and propose their functions. In Japan, transportation projects are done by the private sector, and there is a scheme that makes it difficult to develop one system with the same capital. For that reason, it is necessary to construct an advanced MaaS system with a higher degree of distribution and cooperation among subsystems. We named the system co-creation autonomous distributed system. This system can have “extensibility”, “high quality”, “reliability” and “maintainability”. After several field trials in Japan, we devised a function based on the result. We are currently developing the system and plan to quantitatively evaluate concrete effects through field trials using this system in the future.

KEYWORDS: information linkage, heterogeneous system integration, public transportation, service operability

Novelty of this research

The study suggesting the virtual linkage of the whole public transportation system in Japan is performed for the first time, and its diversification and dispersion is high especially in Japan. It is difficult to standardize, but the system architecture of public transportation having merits in its cooperation has never been examined before.

Utility of this research

We will make concrete proposals for constructing system concepts and system architectures when cooperating across information systems constructed by different ideas. We propose a sustainable and extensible MaaS system architecture, especially taking into consideration the system operability not only during development but also during operation after development and system expansion. Enabling the cooperation becomes possible especially in Japan where the degree of distribution of businesses is high and public transportation services are enriched, which is not only useful, but the standardization at the time of collaborating beyond national and transport modes in the future has already been completed and we suppose this concept can also be applied to subsequent expansion etc.
1. Introduction

Japan has a population of 120 million people and an area of 377,971 square kilometers. In particular, the Tokyo area with the capital has a population density of 6,123 people/square kilometer, and advanced transportation networks are in place to support highly developed economic cities. Also in other cities transportation is being maintained along with the road network. However, each transportation network has been subdivided into 150 models of railway operators, 800 bus companies and 15000 taxi operators in Japan, due to the circumstances of conversion from national government to a model operated by private sectors. Of particular importance is the competitive relationship between the private sectors. It is clear that one standardization and one integrated system are desirable for social implementation of MaaS. However, we thought about the methodology to realize advanced transportation system drawn in MaaS, even though its standardization and integrated system were difficult to achieve. However, we thought about the methodology to realize advanced transportation system drawn in MaaS, even though its standardization and integrated system were difficult to achieve. We will introduce the background from the next chapter, the situations in Japan, and the invented system.

Regarding the definition and system of MaaS, reference is made to the following documents.

- "Exploring the Opportunity for Mobility as a Service in the UK” Transport Systems Catapult(2016)
- "Deliverable Nr 2 – European MaaS Roadmap 2025”, VTT Technical Research Centre of Finland Ltd. (2017)
- Sampo Hietanen, Sami Sahala,”Mobility as a Service, Can it be even better than owning a car?”, ITS Canada

1.1 Difficulty of implementing MaaS model in Japan

Public transportation in Japan has contributed to the development of the Japanese economy by adjustment of the routes and improving services following the postwar reconstruction. During the development process, the problem of lack of state-owned railway operators and bus operators emerged, and privatization and division were attempted as countermeasures. It depends on the calculation method, however if we classify only by the capital, we will see that about 150 railway enterprises, about 800 bus operators and about 15,000 taxi operators existed that time which was pretty big amount in the world. There are various factors such as policy decisions of that time, but as a result, the management structure was improved by introduction of market and competition principles for the private business, and the user service was also improved. Therefore, when the profit decrease following the decline in number of customers, judgment is made by private enterprises, cost reduction measures and consolidation of routes are carried out. Even now, the metropolitan area can secure and survive profits, but some local public transportation systems are forced to withdraw due to the deficit or forced to abolish the line. Therefore, by revising the bill to revitalize regional public transport in 2014, as an administrative institution to support public transportation services of private enterprises, and creating opportunities to consider regional public transport, introduction of sharing mobility and regional on-demand buses by administrative organs are beginning to be considered.
1.2. The state of public transport information system in Japan

Since the above-mentioned public transportation business operates on a per-carrier basis, the information system is also basically developed independently. Below, we will describe the current situation and the presence/absence of the integrated system together with its scheme for each category of information system. As an integration scheme, we categorize the case as “broker” which is converted through an intermediary system or brokerage business and is unified, and “standardization” which matches specifications at the output part. In addition, this situation was surveyed in August 2017 from hearings and cases with major business operators, which showed the possibility of several cases not being in line with this result or there may be different circumstances at present depending on the business.

Table 1. Status of information systems in Japan

<table>
<thead>
<tr>
<th>Category</th>
<th>Status of each information system</th>
<th>Status of integrated system</th>
<th>Integration scheme</th>
<th>API(External)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railway</td>
<td>Timetable</td>
<td>Dispersion</td>
<td>Yes</td>
<td>Mediation</td>
</tr>
<tr>
<td></td>
<td>Operation information</td>
<td>Dispersion</td>
<td>Yes (partially)</td>
<td>Mediation</td>
</tr>
<tr>
<td></td>
<td>Electronic payment</td>
<td>Dispersion</td>
<td>Yes (partially)</td>
<td>Standardization</td>
</tr>
<tr>
<td></td>
<td>Seat reservation</td>
<td>Dispersion</td>
<td>Yes (partially)</td>
<td>Mediation</td>
</tr>
<tr>
<td></td>
<td>Information about location</td>
<td>Dispersion</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Congestion information</td>
<td>Dispersion</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Bus</td>
<td>Timetable</td>
<td>Dispersion</td>
<td>Yes</td>
<td>Mediation</td>
</tr>
<tr>
<td></td>
<td>Operation information</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Electronic payment</td>
<td>Dispersion</td>
<td>Yes (partially)</td>
<td>Standardization</td>
</tr>
<tr>
<td></td>
<td>Seat reservation</td>
<td>Dispersion</td>
<td>Yes (partially)</td>
<td>Mediation</td>
</tr>
<tr>
<td></td>
<td>Information about location</td>
<td>Dispersion</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Congestion information</td>
<td>Dispersion</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

1.3. Regarding the utilization of public transport information in Japan

In Table 1, data output from a business operator is described, but it is possible to create more convenient data and information contents by making use of such information.

Currently offered services and API offer cases.
1.3.1. Route search service

When designating the departure place and destination of the user, the shortest/lowest route is displayed. It is based on the basic planned timetable and does not correspond to the delay of the train. There is also a service to incorporate some operation information and to exclude the overlapping section.
Source data: timetable, operation information
API Provided Case: Yes

1.3.2. Operation information distribution service

The operating information of each company is displayed (normal operation, delayed, operation stops) in a list and push delivery etc. for smartphones. Currently, there are many undeveloped routes for railway lines and bus lines.
Source data: Operation information
API Provided Case: Yes

1.3.3. Real-time location information providing service

Providing location information of individual trains and buses. Provide the information about current section and time of delay to smartphone.
Source data: location information
API provided case: partly available

1.3.4. Real-time congestion information service

Provide congestion information on individual trains and buses. Although it is not so popular yet, there are cases where the service began around 2014
Source data: congestion information
API Provided Case: None

1.3.5. Congestion prediction service

Estimate the congestion degree of specified vehicles and routes from various data. Various methods including the approach from traffic flow prediction, log data utilization of real time data and coexist.
Source data: traffic survey results, real time log data, external data etc.
API Provided Case: None

1.3.6. Reserved seats comprehensive comparison/booking service

We can make comparison of the situation and reservation of the designated seats for multiple enterprises. It is mainly done by air and ferry, long-distance bus etc.

In Japan, traffic information is roughly classified into two schemes
1. Transport operators provide the service to users
2. Business is performed by enterprises other than transportation companies
Table 2 classifies the situation of traffic information service currently provided. This table is still at the stage of survey. Besides, in some cases, it is set to ◯, so it is not based on all the circumstances and it judges only whether or not it is generally popular.

Table 2. Status of Traffic Information Service in Japan

<table>
<thead>
<tr>
<th></th>
<th>1 Transport operators</th>
<th>2 Other than transportation operators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timetable</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>Operation information</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>Electronic payment</td>
<td>◯</td>
<td>×</td>
</tr>
<tr>
<td>Seat reservation</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>Location information</td>
<td>◯</td>
<td>△ (partially)</td>
</tr>
<tr>
<td>Congestion information</td>
<td>◯</td>
<td>×</td>
</tr>
<tr>
<td>Bus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timetable</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>Operation information</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Electronic payment</td>
<td>◯</td>
<td>×</td>
</tr>
<tr>
<td>Seat reservation</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>Location information</td>
<td>◯</td>
<td>△ (partially)</td>
</tr>
<tr>
<td>Congestion information</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Railway and Bus Route Search</td>
<td>×</td>
<td>◯</td>
</tr>
<tr>
<td>Integrated seat reservation</td>
<td>×</td>
<td>◯</td>
</tr>
<tr>
<td>Integrated location information</td>
<td>×</td>
<td>◯</td>
</tr>
<tr>
<td>Integrated operational information</td>
<td>×</td>
<td>◯</td>
</tr>
<tr>
<td>Congestion forecast information</td>
<td>△ (Not enough)</td>
<td>△ (Not enough)</td>
</tr>
</tbody>
</table>

As it becomes clear from above, various information has been broadcasted in Japan, but it is necessary to convert and mediate individually by each business operator, and integrated services are often done by non-transportation companies, MaaS. In constructing the model, it is clear that cooperation between transportation companies as well as other than transportation companies is indispensable.
2. Preliminary research and organization of heterogeneous data integration

I referred to the following two papers as a Japanese articles.

1. *Heterogeneous system cooperation function in IT infrastructure for smart city*(2014)
   It discusses the foundation for mutual cooperation of social infrastructure suppliers and demand side systems, devices and applications in the Smart City-based power field. In particular, not the value between DBs, resolve the incompatibility between DBs due to system change and specification change. Mapping between data classes and attributes in each data model, and transformation such as values / units define a transformation framework structure that can be commonly utilized. By registering a data synchronization job for each data item and setting it as processing for data synchronization as a job, we are not aware of the difference in update timing in data copy and synchronization between DBs of different systems.

2. *Common vocabulary base that promotes utilization of heterogeneous data and information linkage between administrative systems* (2015)
   A common vocabulary base with databases and various APIs to organize the notation, structure and meaning of terms, restrictions on notation etc as vocabulary data, to share data format. Store and provide vocabulary data maintained in a logical format independent of the data format in a format that is easy to use according to users and their uses.

The following is a summary of data processing methods from two articles

1. *Date Cleaning: Problem and Current Approaches*(2000)

Data inconsistencies are classified into “single data source”, “multiple data source” and “respectively schema level, instance level”.

The following are defined as data cleaning approaches

1. analysis
   Analyze the data to decide which error or contradiction to remove

2. Define transformation workflow and mapping rules
   Perform numerous data conversion and cleaning procedures depending on the number of data sources, heterogeneity, data contamination
   First fix the single source instance problem
   Next, it performs schema, data integration and cleaning of inconsistency of multiple source instances

3. Verification
   Test and verify the accuracy and effectiveness of conversion workflow and mapping rules
   Analysis, design, verification may require multiple iterations

4. conversion
   Convert workflow, perform mapping and update data warehouse

5. Reduce data after data cleaning
Replace the original dirty data with clean data from which errors have been removed so that future data cleaning will not be repeated.

Examples of solutions for data inconsistency include the following.

1. Split Case
Unreformed fields often get values for multiple items, instance matching or deduplication is for France

2. Validation and qualification of input instances
Check and fix data entry errors in each settlement instance. Perform spelling checks based on dictionary searches and correction of address data based on dictionaries relating to place names and postal vans

3. Standardization
Convert attribute values to a consistent and uniform form. For example, convert date and time entries to a specific format, convert string data such as name to uppercase or lowercase.

As will be described later, in the state where the transportation company has independently designed in Japan and has not been standardized among the operators, “map data” “railway, bus time data, route data” necessary for navigation “operation information And position information “are distributed and generated, and assuming that specifications are different, the following problems are assumed. As a service to be realized, it is assumed that “path planning”, “real-time situation transmission”, “prediction such as delay and congestion”.

- Name mismatch of map information and time information
- Route search and train ID mismatch
- Duplicate use of train ID
- Difference between the operational station and the route ID and passenger information ID
- Data propagation delay
- Data inconsistency

3. Challenge to cooperate with public transportation information gathered until now.

The authors are working on the issue of cooperation beyond the scope of public transport operators since 2013. In cooperation with multiple operators in 2013 and 2015, the authors integrated real-time data and experimentally developed integrated applications and conducted social experiments.

The experiment purposes are as following
- Evaluation of the effectiveness of integrated services
- System problem extraction at integration

In addition to calculating the development costs and operating expenses of the integrated system and evaluating its effectiveness from the viewpoints of “Transportation companies”, “Regional administration”, “Users”, “Service providers” it became possible to realize the MaaS model we have drawn a roadmap for. As an object, we conducted experiments mainly on information provision service.
3.1. Regarding the demonstration experiment in Kashiwa city, Chiba prefecture in 2013

In accordance with Intelligent Transportation Systems World Conference 2013 held in Tokyo, Japan, we conducted a social experiment of public transport information cooperation using Kashiwa City, Chiba Prefecture as a field. Two railway operators and two bus operators entering a medium-sized terminal station called Kashiwa station, the University of Tokyo and the Kashiwa City Hall Traffic Policy Division worked together to provide smartphone applications and a large-scale gathering of customers feedback. We operated the service for 3 months and gathered feedback from 4000 people who used it. As a service, more than 80% mentioned the necessity of cooperation, and we could confirm such features of service as the increase of access logs at the time when public transportation was disturbed due to heavy rain and other factors.

3.2. Regarding demonstration experiment in Tokyo area in 2015

We carried out a large-scale demonstration experiment using a large terminal station such as Tokyo station and a station of a bed town such as Musashi-Koganei station as its field. Three railway operators, seven bus operators, the University of Tokyo, administrative agencies, etc. collaborated in order to evaluate the effectiveness and summarize the tasks. Approximately 3,000 people got used and got nearly 4000 evaluation results. For this collaborative service, we confirmed the intention to use more than 95%, and confirmed the high demand from the user’s point of view, especially in cooperation of public transportation in Japan.

3.3. Approach to open data

In FY 2013, together with the above verification, we also provided data to the open data study group in Japan and examined it. In cooperation with a system company, etc. that organizes data, we examined the data discrepancy and operation between each business operator.

3.4. Issues and analysis obtained from demonstration experiments etc.

Since standardization was not performed and cooperation schemes were not organized, problems on various services occurred and we were asked for correspondence. Analysis of these experiences and the current information system group gave the following subjects. Today, public and private open data initiatives are also conducted in Japan, providing data that can be output on best effort. When the system operation is performed and the system that guarantees reliability is defined as the main system and the system operation level is low and the condition when system operation is not guaranteed, reliability is defined as the subsystem, the current settlement system will require the main system output. Integrated services are being handled as the main system, but the information providing service is not provided by the subsystem, and the subsystem operation is used as the integrated system.

<table>
<thead>
<tr>
<th>Type</th>
<th>Each output system</th>
<th>Integrated</th>
<th>Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type①</td>
<td>Main system</td>
<td>Main system</td>
<td>None</td>
</tr>
<tr>
<td>Type②</td>
<td>Main system</td>
<td>Sub system</td>
<td>Conversion logic of integration part</td>
</tr>
<tr>
<td>Type③</td>
<td>Sub system</td>
<td>Main system</td>
<td>Operating output systems</td>
</tr>
<tr>
<td>Type④</td>
<td>Sub system</td>
<td>Sub system</td>
<td>All problems</td>
</tr>
</tbody>
</table>

Table 3 Classification of Main System and Subsystem

The main system defines errors, master data, and discrepancies between data servers as managed states.
Subsystems are subject to data output, but may be affected by specification changes or system changes, and are not guaranteed.

Development time
- Difference in data specification definition
- Permanent data loss
- Difference in data ID and name

After development end
- operation
- Primary loss of data
- Difference due to change of ID or name of data
- Data specification change

The tasks at the time of data integration are roughly divided into the following two categories.
- Instance level: sequential tasks
- Schema level: challenges as specification

It is summarized in Table 4 below.

<table>
<thead>
<tr>
<th>Task event</th>
<th>Type of tasks</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>System development</td>
<td>Difference in data specification definition</td>
<td>Schema</td>
</tr>
<tr>
<td></td>
<td>Permanent data loss</td>
<td>Schema</td>
</tr>
<tr>
<td></td>
<td>Difference in data ID and name</td>
<td>Schema</td>
</tr>
<tr>
<td>Service operation</td>
<td>Date fault</td>
<td>Instance</td>
</tr>
<tr>
<td></td>
<td>Due to changes in data ID and name</td>
<td>Schema</td>
</tr>
<tr>
<td></td>
<td>Change of data specification</td>
<td>Schema</td>
</tr>
</tbody>
</table>

If we make an analysis from the business evaluation of these system architectures, we will see there is a situation when the integrated system is constructed as the main system and cannot be the main system of the output system. As an example, if the main system of an individual business entity has already been constructed...
and there is a requirement which can not be replaced by that specification, there is no motivation to fix the existing system for the purpose of cooperation with another system. Also, when constructing a system that integrates public transport as a whole within Japan, there are possibilities that the integrated system: main, output system: main will not be the same, depending on the process of establishing the system. From the above, in order to realize the Japanese MaaS model, in order to achieve sustainable and more advanced public transportation cooperation effect on the premise that the integrated system or the output system is the operation of the subsystem, its extensibility and altitude. It is necessary to share and realize among the stakeholders, including the theoretical construction of the system architecture including the conversion and including them in the roadmap.

4. System architecture, agent system created by receiving analysis results

If it is considered as standardization or one system, it will be as shown in Fig1 (left). However, since the MaaS system as an aggregate of subsystems has the same reliability as that of the main system, logic for solving several problems is required.

Basically, each server and system has a response function from an external agent. This function autonomously controls each distributed system. Since this is a concept that is most suitable for “co-creation” as this existing small system cooperates and does not constitute one large system, the author explains the system giving it the name of “co-creation type autonomous decentralized system”.

Co-creation type autonomous distributed system.

A concept that makes it an aggregate of subsystems and regards it as a system having the same value as the main system. In the realization phase of the MaaS model, it becomes a concept to be utilized when commonality and standardization are difficult. Especially in Japan, even though it was a basic information system, this concept is thought to work effectively. It consists of five basic functions, and explains each function. Focus range is the present assumption as “coordination of plan data”, “cooperation of real time data”, and “improvement of operability of data cooperation/ analysis result”. Conversely, the pre-settlement system has been already standardized and made common in Japan, so it is out of the scope of the current situation, but in the future when cooperating with other financial services etc., it will be within the focus range. In addition, as there is a possibility of utilizing the road system and the map data in the information provision service, the range to be considered is specified according to Table 5 at this stage.
Table 5 Current scope of co-creation autonomous distributed system

<table>
<thead>
<tr>
<th></th>
<th>Plan(Static)</th>
<th>Realtime</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railway</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Bus</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Road</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Taxi</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Map</td>
<td>○</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Ticketing</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
</tbody>
</table>

4.1. Master data management

The master data management function makes requests from external agents to the columns of databases of each data server and application server, definition of data specification level, etc., and performs data acquisition and difference management. In particular, we focused on differences and correction mistakes in data groups with different update frequencies. As an example, in the case of railway system data, it is assumed that the new station name reflecting the latest data from the operator is shifted in reflection timing with the map type data maintained by original research. Also, similarly, the station name and section name of real-time data are always up to date, so inconsistency with map-related data for which update frequency is determined (in Japan, there is a point once a month) many occurred.

4.2. Propagation delay management of real-time data

As for real-time data of trains and vehicles, there is a delay related to the actual traveling position. Besides, in case you pass through the server, the magnitude of the error increases by that amount. For this reason, it is necessary to manage the data generation time and the time until the data is transmitted to the display side for confirming the consistency of the data including the transmission delay. Particularly when combining data coming from different lines and combining them as a service, it is difficult to establish as a service without this concept, and it is also an important factor when used as source data of statistical analysis and prediction information.

4.3. Sharing alerts during service operation

Alert management of server malfunction is performed in basic output system and cooperation destination system. However, depending on the level, operations may be performed without being shared by collaborators, especially when both the output system and the integrated system are assumed as subsystem premises, the tendency is noticeable, which leads to the situation when neither transport operator nor the integrated business operator notices that the erroneous data are continuing to be delivered. To solve this problem, we surveyed a method of distributing alert state from upstream to both data transmission and a method of collectively managing each alert in foreign agent. There are cases in which data connection is not made at the time of a server malfunction, but there is a task to enable server 3 from server 1 → 2 → 3 to notice the trouble of server 1. As the current assumption, it depends on the reliability design required for real-time data, but in some cases it is important for service providers even if the warning information is minor, so please put it in the data transmission route, including warning. If it is a critical level, it is assumed that it is acquired by the foreign agent and the operation system is taken.
4.4. Establishment of cleansing method at statistical analysis (cooperation with alert).

In this paper, we do not mention the prediction system by utilizing past log data and real-time data, but in general when data is statistically analyzed, data on error should be cleansed so as not to affect the prediction accuracy. In the case of predicting on the basis of a plurality of data, it is common to input them to the prediction engine with the entire amount data, but there is a need to define the period of error and the data group due to the above alert situation and master data difference using the function of cleansing the analysis data. It is assumed that this system reflects the data inside the external agent to the integrated analysis infrastructure.

4.5. Establish reliability measurement of predictive information

For information provision in public transportation area, information that can judge about the future will be rather important than information judging about the present. Therefore, the construction of the prediction system is important for the MaaS model, and dynamic demand forecasts such as when to hold events, whether there are any transportation troubles, whether it is reasonable to use public transportation for large-scale evacuation, etc are important. The reliability of the model predicting usage also becomes important in smart city viewpoint and ride-sharing service supply and demand. Therefore, in addition to improving prediction accuracy in the above cleansing work, logic for determining the accuracy of the prediction system by matching the prediction data with the actual data by the foreign agent is important. With this, convenience is improved for users who use the prediction system, and the service provider can examine the supply-demand balance based on the reliability and precision.

5. Summary

In the first chapter of this document we mentioned the current state of public transportation operators in Japan and the public transportation system. In chapter 2, we set the tasks and analysis to construct MaaS model and make it operational through demonstration experiment of public transportation cooperation and its result analysis. In Chapter 3, the idea of the system architecture to solve those problems and the current scope of coverage. The concept of MaaS is still in the stage when dissemination has begun even in Japan. As mentioned above, it is expected that many problems will arise especially during system development, such as the formation of transportation operators and the relation between traffic administration and private business operators. However, it can be said that MaaS’s “as a service” has the fundamental feature of the “transformation and system which is different in terms of physical division/difference but is regarded as one concept as virtual and service”. It is the domestic transport operator to demonstrate its effect. In this study, the scope will remain in the information and guidance information used for information provision and operation, but this concept will also be expanded when implementing more advanced MaaS models and public transport services and systems within smart city in the future. We will engage in further R&D on the assumption of the cooperation effect in the upper layer.
REFERENCE

3. Sampo Hietanen, Sami Sahala, "Mobility as a Service, Can it be even better than owing a car?", ITS Canada
Mobility as a Service: Comparing Developments in Sweden and Finland

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Abstract

This paper examines how institutional factors influence developments in the field of Mobility as a Service (MaaS). We draw upon neo-institutional theory in order to describe drivers and barriers of MaaS developments in Sweden and Finland. By analyzing similarities and differences across the cases, we identify a set of general implications for MaaS policymakers and practitioners. Developments in Finland demonstrate the importance of top-level support, of inter-organizational collaboration and of trust among key stakeholders. The Swedish case reiterates the need for inter-sectorial collaboration, particularly with regard to creating the right conditions for commercialization, and to involving stakeholders on both strategic and operational levels of the transport sector in developing the vision for MaaS. Lastly, we also assess the utility of the applied theoretical framework, and comment on the necessity of recognizing that both practice-based and structural changes are needed in order to facilitate institutional change.

**KEYWORDS:** Mobility as a Service; neo-institutional theory; drivers and barriers

1. Introduction

Since the concept of Mobility as a Service (MaaS) was introduced in 2014 (Heikkilä, 2014), the term has received much attention in the personal transport sector. During this period, Sweden (SE) and Finland (FI) have acted as global pioneers of MaaS. For instance, the 2014 pilot of UbiGo in Gothenburg (SE) is often referred to as the first in real-life conditions (Sochor et al., 2016), while the 2016 launch of Whim in Helsinki (FI) drew international recognition to the concept (MaaS Global, 2016). However, despite the pioneering roles taken by Sweden and Finland, developments in these two neighboring countries have arguably progressed along different trajectories. Hence, based on 31 stakeholder interviews, we analyze and compare the two cases. In particular, we investigate the role of institutions as key structures given their capacity to bring about differentiated outcomes, with the purpose of identifying a set of general contextual preconditions and stakeholder actions that enable societally beneficial MaaS to flourish. Overall, we aim to address the following research question:

*How have institutional arrangements influenced MaaS developments in Sweden and Finland, and what implications can be drawn from these cases?*

By developments we refer to a broad set of practices including past and present events and activities that can be related to advances of the MaaS concept. By implications, we refer to two things. First, we refer to a set of insights drawn from the two case studies that can benefit public and private sector practitioners with
an interest in promoting MaaS developments. Second, we refer to a set of theoretical implications drawn from the application and assessment of a framework developed in the Swedish project IRIMS (Institutional fRameworks for Integrated Mobility Services in future cities). Here our aim is to further refine the framework by abstracting conceptual insights, again from the Swedish and Finnish cases.

Our paper is divided into five sections of which this is the first. The next section outlines our research approach, including the IRIMS framework and methods. In section three we depict developments in relation to MaaS in Sweden and Finland, followed by outlining, in section four, formal and informal drivers and barriers that have influenced the two processes. In section five we propose general implications for other cities, regions and nations with an interest in MaaS, prior to discussing the applicability of the utilized conceptual framework. Lastly, we provide some summative concluding remarks.

2. Research approach

2.1. Conceptual framework

The IRIMS framework (hereafter IRIMS) (Mukhtar-Landgren et al., 2016, Karlsson et al., 2017) defines MaaS as an integrative concept that bundles different transport modalities into a single, seamless service as a means to provide tailored mobility solutions that cater for users’ travel needs. This includes considerations of both passengers and goods. IRIMS’ central focus is on the various institutional arrangements that act as both driving forces and barriers to the development and deployment of MaaS. IRIMS defines institutions as ‘regulative, normative, and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life’ (Scott, 2013, p. 56). Regulative elements of institutions are things such as laws that impose coercive control by either allowing or sanctioning certain types of activities. Normative elements refer to values and norms that are embedded in certain well-established roles, and exert control via ‘logic of appropriateness’ in certain situational contexts. Cultural cognitive elements are typically experienced as ‘rules of thumb’ among a collective. IRIMS divides these institutional dimensions into formal (regulative) and informal (normative and cultural-cognitive) categories.

IRIMS furthermore delineates institutional arrangements into three additional analytical levels: macro, meso and micro. The macro level encompasses societal institutional arrangements, including laws, policies, taxation and subsidies (formal) alongside culture, national identity and societal trends (informal). In practice, the set of relevant macro-level institutional arrangements includes things like transport regulation, the use of subsidies in public transport (PT), cultures of automobility that vary between countries, and the penetration of new sharing economy ideals. The meso level includes institutional arrangements at the regional and local levels that are embedded in public authorities and public and private service providers including: regional/municipal transport plans and directives, urban planning, and regional innovation grants (formal) alongside the roles and identities of local PT authorities (PTAs), local cultures of collaboration via innovation networks, and the logical components of existing mobility business models (informal). The micro level is that of the individual, referring to the proposed users of MaaS services, i.e. travelers. Institutional arrangements that are relevant at this level include a range of push and pull measures, such as congestion charging, taxation and investments that make certain transport modes more attractive (formal), alongside travel patterns and habitual behavior, self-images, subjective norms and social status (informal).

Despite the use of Scott’s definition of institutions, IRIMS focuses more on the rule-like features of institutions that constrain and enable practices. However, Scott’s definition of institutions captures their rule-
like features (structures) alongside activities, actions and rituals (practices). This more nuanced understanding acknowledges that the rule-like features of institutions are *intertwined* with the practices they depict as legitimate – institutions also encompass ‘routines, procedures, conventions, roles, strategies, organizational forms, and technologies around which…activity is structured’ (March and Olsen, 1989, p. 22). Hence institutions can be divided into two realms – institutionalized *structures* and the material realm of *practice*. The two realms are deemed ‘mutually constitutive’ (Meyer et al., 1994), such that in processes of institutional change, there are adjustments in both realms.

As a consequence of IRIMS comprising a meso level, it acknowledges one type of practice that, alongside the structural aspects of institutional arrangements, is critical the development and diffusion of MaaS. That is, to realize the development of MaaS, there is a need for business model innovations that are based on a new set of inter-sectorial collaborations. Hence, IRIMS notes the importance of collaboration in new business ecosystems (cf. Moore 1996). IRIMS characterizes collaboration as ‘a process where various stakeholders from different public, private (and/or public/private hybrids) as well as civil society organizations (i) combine capacities, recourses and expertise and (ii) work together with the common goal to implement a solution or policy or to solve problems of an inter-organizational character’ (Mukhtar-Landgren et al., 2016, p. 13).

### 2.2. Research gap

Until now, little work has been done to identify the way in which institutions influence collaboration in emerging MaaS ecosystems. It is, however, increasingly understood that MaaS necessitates the creation of new roles and associated responsibilities (i.e. practices), such as that of a MaaS operator and integrator (cf. Smith et al., 2017a). Here the question of who takes the role of MaaS operator is a particularly sensitive issue, since some existing transport service providers view MaaS as a potential threat in terms of brand, image and customer relationships. Hence a discussion has emerged regarding roles in the ecosystem, and scholars have noted that different models for ecosystem collaboration may emerge in different contexts (e.g. Holmberg et al., 2015; Kamargianni et al., 2016). In these different models, a common theme is the discussion of the division of roles between private actors and public organizations. For instance, Smith et al. (2017a) outline three ways in which MaaS developments may evolve: via market-driven activities; as a result of state interventions; or as part of public-private collaborations. Regardless of the scenario in question, there exists bidirectional influence between collaboration (a practice) and institutional arrangements (structures). That is, practices are enabled and constrained by existing structures but also have the potential to transform those very structures. Yet IRIMS is silent on the interactions between changes in structure and practice, and how these may influence MaaS developments. In this paper, we examine the relationships between structure and practice, and comment on their relevance for MaaS developments.

### 2.3. Method

We performed 31 interviews with 34 key stakeholders in Sweden and Finland during the period September 2016 to February 2017. We utilized a semi-structured interview guide to organize the interviews around the three institutional levels recognized in IRIMS – macro, meso and micro – focusing on identifying perceptions of institutional drivers and barriers in relation to the development of MaaS. The interviews lasted between 43 and 112 minutes (average 69) and the respondents consisted of public and private actors directly involved in MaaS developments. The sample is described in Table 1.
In order to analyze the data, we first coded and clustered transcriptions of the interviews inductively in two parallel processes. This resulted in two initial lists of institutional drivers and barriers, one for each case. Then, we applied the IRIMS framework to sort and compare these results. From this exercise, we generated a table describing similarities and differences across the cases in terms of institutional arrangements. Lastly, we revisited individual quotes to decompose and clarify our findings.

3. Background - MaaS developments in Sweden and Finland

Brief summaries of past, present and planned developments in relation to MaaS in Sweden and Finland are described below and laid out in Figure 1, although neither the descriptions nor the figure can capture all relevant developments. Moreover, it should be noted that (i) MaaS developments in Sweden and Finland are entangled, and (ii) both cases are strongly affected by external developments.

3.1. Developments in Sweden

In the Swedish context, the concept of customized, multimodal mobility packages was initially proposed in 2011 within an R&D project entitled ‘The flexible traveler’ (*Den flexible trafikanten*). The project, which examined business opportunities associated with multimodal services and sought to initiate processes for their realization, concluded that the conditions were in place for services that provide metropolitan citizens with comprehensive, reliable, customized and usable mobility services that reduce costs, increase flexibility, and contribute to sustainable everyday travel (Boethius and Arby, 2011). The business concept was further developed between 2011 and 2014 in a two-phased R&D project named Go:Smart (Strömdahl et al., 2014). The second phase of the project comprised a well-documented six-month pilot of a multimodal service in the Gothenburg area, called UbiGo (e.g. Sochor et al. 2014, 2015a,b, 2016).

Concurrently, several actors within the Swedish PT sector were realizing that entirely new approaches to how PT is organized and delivered to citizens might be needed in order to meet the widely adopted goal of doubling the market share of PT within Sweden (Grönlund, 2017). For instance, the current regional PTA (*Västra Götalandsregionen* – VGR) in West Sweden first proclaimed their support for such a goal back in 2006 (K2020, 2009), and later based their regional transport strategies around achieving that goal (Bokeberg et al., 2016; Efraimsson, 2012). However, by 2011, several reports were published at both regional and national levels that demonstrated the discrepancies between existing PT budgets (including the one in West Sweden) and the budgets needed for achieving this goal (e.g. Legerius, 2012). Consequently, key persons at VGR, among others, adopted the view that PT must aim to better attract private investments, which was the basis for their keen interest in the outcomes of the abovementioned R&D projects.

The success of the UbiGo pilot, which ran in 2013-14 under the Go:Smart project, had two main results. First, a company was launched early in 2014, named UbiGo AB, that aimed at continuing the service with

<table>
<thead>
<tr>
<th></th>
<th>Gothenburg</th>
<th>Helsinki</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public sector</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Private sector</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Research &amp; academia</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1. Respondent sample

1 However, at that point they were not the regional PTA – a position they first acclaimed on January 1st, 2012 when PT responsibilities in West Sweden were reorganized and a new PT law was introduced in Sweden.
its existing customer base, then further expanding the service. Second, VGR commissioned its operational company, Västrafik – that had participated in the UbiGo pilot as a transport service provider – to conduct a pre-study to evaluate the legal conditions and potential implications of taking different roles in forthcoming developments. However, this move created uncertainty regarding the relationship between Västrafik and external MaaS operators, which contributed to UbiGo AB being closed down in 2014. UbiGo Innovation AB, a new company with the mission of refining and relaunching the piloted service, replaced it later the same year. Currently, UbiGo Innovation plans to relaunch the UbiGo service in Stockholm as part of a EU-funded R&D project (civitas.eu/eccentric).

For Västrafik, the pre-study led to a decision at the end of 2014 to initiate a procurement process (Frey, 2014). Accordingly, in the spring of 2016, they invited prospective bidders to discuss potential conditions for a service concession agreement regarding a MaaS for West Sweden. After reviewing the response from the participating companies, Västrafik concluded that offering their tickets for resale, without any additional investment on their part, would fail to drive MaaS developments in a direction that would fulfill the doubling goal (Smith et al., 2017b). First, since the investment costs for MaaS operators would be disproportionate (especially if aiming to develop nation-wide offerings) and, second, because a role as transport provider (and nothing else) would leave Västrafik with little opportunity to govern the trajectory of MaaS.

As a consequence, Västrafik teamed up with other regional PTAs in the ‘Swedish Mobility Program’ (SMP). SMP, which is managed by Samtrafiken, aims at developing a national integration platform for transport-related services, i.e. a portal giving MaaS Operators access to transport service data and tickets to include in their MaaS-related offerings. SMP also aims at establishing Samtrafiken as a national MaaS integrator; to co-ordinate a joint business agreement; and to initiate, operate and participate in pilot activities related to MaaS (Samtrafiken, 2017). At present, the integration platform is scheduled for launch in West Sweden in April 2018 and in the counties of Stockholm and Skåne in 2019, if Samtrafiken manages to receive funding for its development and operation.

SMP has also succeeded in promoting the MaaS concept to several key actors. One such actor is the regional PTA in the county of Stockholm (Stockholms Läns Landsting – SLL). In 2016, SLL made a strategic decision to enable MaaS developments in the county of Stockholm, positioning itself as a transport service provider in the MaaS ecosystem. In practice, this decision means that SLL envisages that third parties should take the role of MaaS operators. SLL has made short-term plans to make a selected range of tickets available for third-party resale through deep linking. During 2017, SLL plans to initiate and participate in MaaS-related pilots and to analyze legal, business, technical and time-related aspects of permanently enabling third-party ticket resales. In 2018, SLL also plans to approach politicians with a more detailed implementation plan for MaaS (Palmbeck, 2016).

At the national level, MaaS is a salient issue for the Swedish Ministry of Enterprise and Innovation (Näringsdepartementet). In 2017, one of their collaborative groups (samverkansgrupp) proposed MaaS as a key priority for solving the transportation challenges of the future and established a working group in order to explore potential actions for promoting its development (Näringsdepartementet, 2017). These initiatives led to a national roadmap for the development of MaaS in Sweden (Pernestål Brenden et al., 2017), and a program for overseeing the suggested actions (kompis.me). The roadmap coordinates other strategies, such as SMP and the Swedish Transport Administration’s (Trafikverket) action plan for Intelligent Transport

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2 A joint venture that aims to support coordination of PT in Sweden.
Systems (ITS) (Andersson et al., 2014), in which MaaS is again recognized as a prioritized area. Moreover, the national roadmap for MaaS features in the Swedish Transport Administration’s proposed plan for the development of the transport system in Sweden between 2018 and 2029 (Kalander and Haraldsson, 2017). Lastly, the Swedish Energy Agency (Energimyndigheten) plans to initiate a program aimed at boosting MaaS developments called ‘Challenge from Sweden’ by the end of 2017.

3.2. Developments in Finland

In 2009, the Ministry of Transport and Communications (Liikenne- ja viestintäministeriö – LVM) decided that a major reform of transport market legislation was needed if the public goals for the Finnish transport sector were to be met. The same year, they also authored Finland’s first national strategy for ITS. Among other things, the strategy proposed that an increased use of ITS could realize a versatile transport system that guides citizens towards using environmentally sustainable, economical and safe modes of transport, but that this development required a modern, customer-oriented transport policy (LVM, 2009). Hence, LVM initiated the ‘Transport Revolution’ program, which aimed at developing an entirely new approach for transport policies and policy implementation (Tuominen and Kanner, 2011).

In recent years, the abovementioned ideas have been concretized into proposals. Major legislative modifications have been brought together in a unified act, which LVM has labeled the ‘Transport Code’. Key objectives of the Code are to promote the creation of new service models, ease market entrance, dismantle national regulation that limits competition and reduce the level of public guidance’ (LVM, 2016a, p. 1).

The first phase of the Code, which mainly concerns road transport, was adopted by the Finnish Parliament in April 2017 and will enter into force on the 1st of July 2018 (LVM, 2017). This phase has two parts. First, it aims at lowering permit requirements and tearing down silos between transport markets through deregulation. For instance, the current PT license will be replaced with a passenger transport license; any type of vehicle will be allowed to be used as a taxi, and limits on the number of taxi licenses as well as price regulations for taxis will be removed (LVM 2016a,b). Second, it focuses on enhancing the use of open and interoperable data interfaces. The Code will oblige incumbents as well as new entrants to the transportation market to provide their operational data as well as their single tickets for third-party resale and use. The underpinning idea of the Code is to take advantage of digitalization and enable both the development of better and more agile transport services, and the integration of them into MaaS offerings. LVM proposes that these changes will streamline the public role in personal transport, with the concrete goals of achieving a 10% savings in publicly subsidized passenger transport from 2017 (LVM, 2017).

The development of MaaS is closely coupled with LVM’s work on reforming transport market legislation. The idea of creating multimodal mobility packages was, in the Finnish context, first promoted at a LVM think tank in 2012\(^3\), and LVM has since used the idea of MaaS as the crown jewel of their envisioned future smart transport system. Several members of the think tank began promoting MaaS – ‘the Netflix of transportation’ – all over Finland, but it was first when MaaS was introduced as a key topic at the ITS European Congress in Helsinki in 2014 (Heikkilä, 2014) that it began receiving international attention (e.g. Hellmann, 2014; Wile, 2014).

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\(^3\) The idea was presented by Sampo Hietanen, then CEO of ITS Finland, who later became CEO of Maas Finland Oy, subsequently MaaS Global Oy.
In the beginning of 2015, LVM and the Finnish Funding Agency for Innovation (Tekes) launched a joint program for the development of MaaS. As a first action, Tekes published a call for MaaS operators. Eight pre-studies were funded, and in the end several MaaS-related pilots were performed around Finland during 2015 and 2016. The telecom giant Telia Finland Oy (previously Sonera) developed a MaaS application called Reissu, and conducted two pilots, one for commuters in the city of Hämeenlinna and one for tourists heading to the ski resort Ylläs, before selling the brand to the Finnish company Semel Oy in December 2016. Tuup Oy, a start-up company, launched the first version of a MaaS application in 2016. So far, it enables purchasing PT tickets in Turku and hailing taxis in some areas, as well as exclusive access to Kyyti, a taxi-pooling service that currently is available in Oulu, Turku and Tampere. Sito Oy, a Finnish consultancy firm, piloted a MaaS application, Kätevä, in Seinäjoki between November 2016 and April 2017. The service provided three types of mobility packages that combined local buses, demand responsive transit and taxis. Sito Oy is currently analyzing the results of the pilot.

Still, it is the activities of MaaS Global Oy (previously MaaS Finland Oy) that has received the most attention. In May 2015, 23 organizations partnered to cooperate in the establishment of a company that could take the MaaS operator role. In the end, eight of the organizations invested in the idea and in December the same year MaaS Global was registered as a company. In June 2016, MaaS Global publicly launched its first service, Whim, and began offering it to pilot customers in a beta test in Helsinki from October the same year. Whim customers access regional PT, car rentals and taxis via different subscription packages. PT access was enabled through a business agreement with HSL, the regional PTA, which allows MaaS Global to resell their single tickets. In 2017, MaaS Global raised additional venture capital, and is currently preparing to expand to Amsterdam, NL, West Midlands, UK and Singapore, SN.

In addition to LVM and Tekes’ joint MaaS program, another public actor, Export Finland, has launched a growth program for MaaS, aimed at helping Finnish MaaS-related ventures to attract international investors and to and seize global business opportunities.
Figure 1. Key events in the development of MaaS in Sweden and Finland
4. Results – Institutional conditions

4.1. Macro-level conditions

In Finland, there is an ongoing political movement towards deregulation and increased market orientation. For instance, when entering office in 2015, the current government proclaimed that Finland will be ‘a land of solutions’ (Sipilä, 2015). The government identified three means to achieve this vision: digitalization, experimentation and deregulation. Regarding deregulation, LVM has been investigating a reformation of the transport market for almost two decades and recently succeeded in getting the first phase of the Code through parliament. As a result, there is a strong likelihood that the existing, heavily regulated PT and taxi markets will be opened up. As such, MaaS seems likely to be market-driven in Finland (cf. Smith et al. 2017a).

In Sweden, the PT market has already undergone several phases of deregulation since 1989 (Jansson and Wallin, 1991). The most recent change was in 2012 when, among other things, the rail market was deregulated allowing commercial operators to deliver rail travel on any regionally governed route (Transportstyrelsen, 2012). Ringqvist (2016) notes a tendency towards transport regulation following regulatory cycles with four stages: (i) regulated public monopoly; (ii) competitive private supply; (iii) private sector area monopoly; and (iv) regulated private local monopoly (cf. Gwilliam, 2008). Accordingly, there does not seem to be any shift towards further deregulation in the Swedish transport sector, why the development of MaaS might be more likely to follow a public-controlled or public-private route, compared to the development in Finland (cf. Smith et al. 2017a).

In Finland, communication and transport are governed by the same ministry (LVM). This has enabled the Finnish government to make structural links between transport and ICT. This is not the case in Sweden. Also, the struggling Finnish economy and the nation's long tradition within ICT and digitalization are key to LVM’s interest in MaaS. Since the global financial crisis of 2009, Finland has had one of the poorest performing economies within the Eurozone (Khan, 2015). During this period, ICT and digitalization have been the biggest contributors to national economic growth. Much of the human capital from Nokia has moreover remained in Finland since the telecom giant’s collapse. Hence, LVM has substantial incentives for keeping ICT and digitalization in focus when looking for new recipes for future growth (Leviäkangas, 2016):

After Nokia had sold its mobile phone [technology] and it looked quite grim for the Nokia group itself, we still had a lot of resources in Finland that were interested and knowledgeable in this area [ICT]. So, it is also an institutional explanation, why just Finland; there was a technological and mental maturity to address these problems. And there was some time, people had time. – IP3 Finland (translated)

The development of the Finnish Code has been closely coupled to MaaS developments. Several Finnish respondents noted that LVM in general, and the minister for transport and communications in particular, have paved the way for MaaS development in two ways. First, by communicating a ‘national’ agenda that seeks to enable MaaS development, drawing attention to the concept, and making it easier for start-ups to find investors and to convince transport service providers to jump on the bandwagon. Second, by proposing the deregulations and regulations required to drive the development, such as requiring transport service providers to make single tickets available for resale. Several private sector respondents in Finland also expressed that they felt included in policy developments, suggesting that Finland’s small and centralized nature may be beneficial for such inclusion. These respondents noted that many stakeholders from the transport and communication sectors, including the politicians and civil servants at LVM, know each other well and have strong formal/informal ties, given regular informal meetings.
In contrast, the Swedish government has only recently become interested in MaaS, and existing regulatory institutions have, until now, been perceived as an obstacle that constrains public actors’ action space. This is particularly the case for PTAs (cf. Smith et al., forthcoming). Also, MaaS developments have, so far, mainly occurred in Gothenburg, whereas most government agencies are situated in Stockholm.

Further, MaaS is supported by different rationales in the two countries. In Finland, MaaS is typically motivated by the idea that public spending on transport must be streamlined and that economic growth will result from cross-industry collaborations and sound market competition. In Sweden, MaaS interests are rather the result of the goal to increase the modal share of sustainable modes in general, and PT in particular.

What does Västrafik want to achieve with MaaS⁴: To develop a service that is as useful as possible for the customer. That it should be...that we should be able to reach new customers with this service – those we do not reach today. We have a doubling goal [for PT's market share], which we think this service can help us achieve. – IP4 Sweden (translated)

Finnish respondents argued that the organization of PT in Finland is an institutional barrier to MaaS. In contrast to Sweden, Finland does not have regions. Hence, the responsibility for PT and PT subsidies is either on the state or municipal level. In Finland, single tickets are not subsidized, and each municipality has the responsibility for subsidizing its ‘own’ residents’ PT passes. Hence the PTA in the Helsinki area (Helsingin seudun liikenne – HSL), which is governed by eight municipal political bodies, must keep track of their customers’ places of residence when selling other types of tickets than single tickets. In Sweden, all types of PT tickets and passes are subsidized at the regional level, regardless of the traveler's place of residence.

4.2. Meso-level conditions

During interviews, several Finnish respondents noted the importance of a set of key players, described as ‘MaaS champions’. These actors are positioned in many of the most influential roles within key public and private organizations such as the LVM (both politicians and civil servants), within leading start-ups and at the City of Helsinki. The development of the Code, which is tightly coupled to MaaS development, has been characterized in terms of cross-sectorial discussions between MaaS champions. Finnish respondents also noted the importance of both informal and formal gatherings, and declared how fortunate they were to experience such an open and collaborative climate:

The new minister set up [a] sort of think tank for new mobility [with] high-level people from public and private sectors [and] research. And [the future CEO of MaaS Global] took this idea in there and it really got a flying start in that think tank. …With all that feedback it drove him further. He became the CEO of ITS Finland so it was easy for him to start pushing it more and more, and at the same time the ministry really picked it up, because they saw that this could be something, and then [they proposed] this law [the Transport Code]. We need to be thankful for our ministry because they have been really pushing; they are really one of the main key drivers in the background. – IP4 Finland

In contrast, Swedish respondents did not mention a consistent set of key players (although the CEO of UbiGo Innovation was mentioned during several interviews), and Sweden has, until very recently at least, not created a similar climate of formal/informal collaboration to facilitate cross-sectorial discussions. Further, many key actors in Finland share a vision for MaaS development, whereas very few Swedish respondents spoke of such a phenomenon in Sweden. As a result, there is arguably more tension and mistrust between certain public

⁴ Phrase used in Swedish: combined mobility (kombinerad mobilitet).
and private actors in Sweden than in Finland (Smith et al., forthcoming). In Sweden, this is highlighted by
the UbiGo pilot, which, despite its success, was followed by a lack of consensus over the next steps, and both
VGR’s decision to initiate an innovation procurement procedure and Västrafrik’s subsequent actions have
been heavily criticized by some of the other actors involved in the development of MaaS in Sweden:

They [Västrafrik] lack knowledge and self-awareness. Then it’s also a natural reaction. If you were [situated]
in a development department and loved what you did, and someone asked: Should we outsource this
assignment to an external consultant or would you like to do it at the department? ...It was a bit like putting
a wet blanket on the whole [development of MaaS in Sweden]. – IP10 Sweden (translated)

Analysis of the meso level highlights two major barriers that are consistent across each case. First, the
fact that the PTAs do not allow for third-party ticket resales is seen as a major obstacle to MaaS, both in
Sweden and Finland. Although HSL has developed a contract to release single tickets, so far only signed with
MaaS Global, and several PTAs in Sweden plan to provide their tickets through the SMP platform, PTAs’
unwillingness to cooperate is often portrayed as the main decelerator to the commercialization of MaaS.
Respondents also cited technical issues as part of the problem, such as a lack of reliable open data and the
non-existent standardization of interfaces. Respondents argued that the PTAs’ obstinacy on the ticket resale
issue is primarily related to a protectionist mindset, risk aversion and organizational inertia. That is, PTAs
do not want to risk market shares and customer relations, and are slow at adapting to changed circumstances,
which is generally due to the nature of publically administered bureaucracies. Several respondents were of
the opinion that PTAs are afraid of losing monopoly positions and losing control of the transport sector:

That’s the biggest problem in transport, everybody thinks that ‘we have to be in power’. When I talk to the
train-sharing monopoly they say; ‘yeah, we need to control the customer, we need to control this market, we
need to control’. Look, you can’t! – IP9 Finland

Second, uncertainty regarding MaaS business models was probably the most heavily discussed barrier in
each case. Respondents argued that MaaS business models that promote sustainable travel and are beneficial
for different transport service providers are the cornerstone of MaaS’ future success. This includes the
division of roles and responsibilities among incumbent actors and new entrants. Several respondents noted
the importance of one key factor linked to MaaS business models – costs associated with marketing new
services (and brands) to increase visibility and attractiveness among potential users:

If you want to create a sort of a global, or even a regional service, you would need to have a visible brand
that you build on. That’s a very...challenging game, because you need to create a lot of awareness among the
users, you need to do a lot of marketing, and we saw that it’s easy to get visibility with these kinds of things,
but to really gain those customers and keep them, well that’s a big challenge. – IP7 Finland

4.3. Micro-level conditions

Neither Swedish nor Finnish respondents professed much knowledge about end-users. Rather, respondents
saw the need for further pilots to learn more about users’ attitudes, preferences and behavior. In both cases,
respondents debated whether or not potential users are ready to adopt MaaS. More skeptical respondents
questioned whether current problems in the form of congestion, parking hassles and transportation costs
are adequately significant to motivate a shift towards servitized solutions. They also claimed that mental
models favor sticking to private car use, and that it is very difficult to compete with the ‘mobility insurance’
that owning a private car provides. Skeptical respondents argued that it will take a long time to change
user preferences, and that Finland having the oldest car fleet in Europe is indicative of Finns’ resistance
to change. In contrast, more optimistic respondents claimed that the private car is an ill-suited and costly solution to everyday mobility needs, which many users would rather be without. Further, these optimistic respondents mentioned that the penetration of smart phones; decreasing interest in driver's licenses among younger generations; and the general success of servitized businesses are good indicators of the readiness of the market.

5. Discussion

Our study utilized the IRIMS framework to identify a set of institutional conditions that act as drivers and barriers of MaaS developments in Sweden and Finland (summarized in Table 2). A comparison of the two cases highlights structural differences that, when considered in terms of their historical importance, have led to different paths for MaaS in Sweden and Finland. It is interesting to note that MaaS developments in Sweden initially preceded those in Finland, yet one might reasonably argue that Finland has seen more tangible and recent MaaS-related action. Our analysis reveals several reasons for this. At the macro level, in Finland, the reformation of the Transport Code, combined with the development of a strong vision that is shared by a wider collective of key actors (MaaS champions) situated within key organizations in the public and private sectors, has been a strong enabler of MaaS development. The creation of a vision that identifies MaaS as a source of a new potential growth trajectory that unifies the ICT and transport sectors in Finland, in the context of a dire need for economic renewal, is supportive of these developments. Hence, we argue that the political climate (deregulation of the transport sector) and prevalent challenges (enabling growth within ICT and streamlining public spending to offset the economic downturn) have been successfully matched with the proposal (MaaS) in Finland, thus opening up the needed window of opportunity for policy change (cf. Kingdon 1989). In contrast, Sweden does not have the same need for economic renewal, as the economy has escaped the downturn relatively unscathed. Moreover, Sweden does not have a unifying vision for MaaS; nor does it have formal networks based on strong informal ties; and there is a lack of MaaS champions in key positions. Rather MaaS in Sweden is increasingly framed as a means to assist PT growth.

The difference in the underpinning rationales for MaaS in the two countries is arguably an effect of incumbent PT actors having a more front-seat role in the Swedish MaaS development, compared to the development in Finland. Naturally, PT actors are more focused on improving the existent PT regime and fulfilling incremental growth goals. This can be contrasted to start-ups, innovation agencies and government ministries who are keener on revolutionizing the transport sector and fulfilling visionary targets such as replacing the private car as the go-to solution for mobility. Notably, no representative of the incumbent PT actors was mentioned amongst the group of Finnish MaaS champions, and the Finnish PT sector has had little involvement in either the preparation of the Transport Code or the creation of the MaaS vision in Finland. Hence, one may anticipate that the Finnish development of MaaS might soon face similar disagreements regarding the roles of private and public actors, as has been the case in Sweden (where PT actors have been involved in the development of MaaS since the UbiGo pilot). For instance, although Whim was launched more than a year ago, MaaS Global is still to succeed in convincing HSL to provide more than (unsubsidized) single tickets. As a consequence, MaaS Global has not yet been able to go beyond offering Whim to a group of pilot users.

The two cases highlight a similar set of formal institutional barriers at the meso level. MaaS ecosystems, though emerging, are largely disjointed and there is an air of protectionism and risk aversion among transport service providers (particularly PTAs), resulting in an unwillingness to allow third parties to resell tickets, a lack of open data, and as a natural consequence, uncertainty regarding the viability of emergent MaaS
business models. In both cases, uncertainty regarding the size of the MaaS market and its potential is the result of a lack of knowledge regarding users and their willingness to adopt MaaS as a genuine alternative to private vehicle use.

<table>
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<tr>
<th>Macro</th>
<th>Formal</th>
<th>Informal</th>
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<tbody>
<tr>
<td>The revised Transport Code (FI)</td>
<td>+</td>
<td>Optimistic shared vision (FI)</td>
</tr>
<tr>
<td>The existing regulatory system (SE)</td>
<td>-</td>
<td>Lack of a shared vision (SE)</td>
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<tr>
<td>Public funding of pilots (FI + SE)</td>
<td>+</td>
<td>Presence of MaaS champions (FI)</td>
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<td>Lack of MaaS champions (SE)</td>
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<td>Drive for economic renewal (FI)</td>
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<td>Drive for sustainability in transport (SE)</td>
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<td>Meso</td>
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<tr>
<td>Lack of channels for ticket resales (FI + SE)</td>
<td>-</td>
<td>Cross-sector collaboration (FI)</td>
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<td>Lack of viable business models (FI + SE)</td>
<td>-</td>
<td>Public-private divide (SE)</td>
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<td>Lack of data &amp; standards (FI + SE)</td>
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<td>Risk aversion in ecosystem (FI + SE)</td>
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<td>Private investment (FI)</td>
<td>+</td>
<td>Informal networks among key actors (FI)</td>
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<td>Lack of trust and social capital (SE)</td>
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<td>Micro</td>
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<td>Uncertain market potential (FI + SE)</td>
<td>-</td>
<td>Existing user habits (FI + SE)</td>
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Table 2. Summary of influential institutional arrangements (drivers denoted “+” and barriers “-”)

5.1. Practical implications

While our case studies reveal several conditions that are highly contextual, they can also be used to identify a set of generic institutional arrangements that influence MaaS development. That is, policymakers and practitioners with an interest in promoting MaaS developments should focus on the following:

1. Engaging a broad set of strategic and operational key stakeholders that have the mandate and discretion to govern MaaS within and beyond their own public/private sector organizations;
2. The creation of formal and informal networks based on geographical proximity to the centers of power and which are conducive to the creation of trust and social capital;
3. Creating a strong vision for MaaS that tackles sustainability problems in local/regional/national contexts;
4. Using and iteratively revising this vision to create a climate of open innovation within the MaaS ecosystem, where risks are translated into business opportunities for transport service providers;
5. Supporting pilots and implementations with financial capital from the public and private sectors;
6. Experimenting with new institutional arrangements (e.g. the redistribution of subsidies for PT) that are conducive to MaaS developments and sustainable travel behavior;
7. Learning as part of an interactive, co-creative process that aims to develop MaaS services and associated business models that are attractive to users.

These implications are not an exhaustive list; nor are they separate from one another. Rather, they should be seen as a set of interacting institutional arrangements that can be combined to support MaaS development. For example, the creation and iterative revision of an overarching vision for MaaS, based on the developments of services and incentives for sustainable travel behavior (i.e. shifts to more sustainable modes such as car sharing, PT, cycling and walking) may be key to overcoming protectionism and risk aversion among different types of transport service providers. That is, if it can be shown through pilots that MaaS will attract new users from the current private car segment, then transport service providers will likely see MaaS as an opportunity to attract new users rather than see their offerings and their brands as potentially cannibalized...
by the collaborative approach that MaaS entails. It is indeed important to remember that the development and deployment of MaaS is not necessarily a goal in and of itself. Still, long-term commitments from PTAs that go beyond piloting might be needed in order to attract private investments. Hence developing MaaS offerings that both encourage environmentally sustainable changes to travel behavior and build upon viable business models may be key to unlocking the potential of the MaaS ecosystem.

The set of institutional drivers and barriers outlined in this paper occur at the macro, meso and micro levels, and despite linkages between these levels, it is clear that no single actor can govern a transition to a MaaS-based transport system in any given setting. Rather, our findings advocate a multi-stakeholder approach to governance, where networks of actors (MaaS champions) must act in concert to bring about the necessary institutional changes. Further, an understanding of institutions as consisting of both structures (legislation and policies, networks and roles, norms and culture) and practices (the creation of visions, experimentation, collaboration, changes in travel behavior) is required for effective governance, such that the development and diffusion of MaaS, as a radical innovation, must be seen as a process of institutional change. Hence in the next section we explicate a set of theoretical implications that may further inform practitioners.

5.2. Theoretical implications

From our analysis, it is clear that the IRIMS framework is useful for identifying the structural elements of institutions that influence MaaS development. However, one major shortcoming of IRIMS is that it obscures the practice-based elements of institutions, i.e. institutionalized roles, norms, behavior and cultural understandings that must change in order for MaaS to flourish. In order to give analyses of institutional effects practical utility, it is necessary to consider how a transition to MaaS may be governed, and a theoretical framework that includes both the structural and practice-based elements of change processes is required. To this end one may draw on the literature on institutional entrepreneurship (e.g. Battiliana et al., 2009) to examine how collectives bring about institutional change. Alternatively, one may draw insights from transition theory, and particularly transition management (Kemp and Loorbach, 2007a; Loorbach, 2010; Loorbach et al., 2010; Loorbach and Wijsman, 2013; Rotmans and Loorbach, 2008) Broadly, this framework espouses a long-term approach to sustainable transitions, based on strategic, tactical, operational and reflexive activities. Strategic activities are collaborative, multi-stakeholder processes, which aim to ensure that long-term visions are shared and embedded among collectives. In contrast, tactical activities serve to link individual actor strategies to the shared long-term visions created via strategic activities, aiming to overcome short-termism within different societal sectors (e.g. politics, business). They also aim to tackle the difficulties in implementing solutions by acknowledging complex sources of inertia within regimes, and directing activities such as corporate political action and lobbying towards the reformation of such structures. Operational activities aim to link everyday activities such as innovative experiments to long-term visions, broader policies and change agendas. Reflexive activities include the ongoing monitoring, assessment and evaluation of policies and practices as a means to revise overarching visions and plans where necessary (Kemp and Loorbach, 2007b; Loorbach, 2010, 2007; Rauschmayer et al., 2015; Rotmans and Loorbach, 2008; Voß et al., 2009). Our findings show that these types of practical activities are central to MaaS development. Theoretically, this implies that frameworks such as IRIMS can be further developed to include elements of practice that can, together with structural changes, bring about institutional change. Practically, one could draw on transition management by, for instance, anchoring the approach among the multiple stakeholders that are key to governing MaaS developments.
6. Concluding remarks

Despite similar pioneering roles in relation to MaaS, developments have arguably progressed along different trajectories in Sweden and Finland. In Sweden, MaaS is primarily discussed as a tool for enhancing the attractiveness of servitized transport in order to meet growth goals for sustainable transport modes in general, and for PT in particular. In Finland, MaaS is rather seen as a new transport paradigm that can enable growth within ICT and streamline public spending to offset the economic downturn. As a consequence, Finnish developments have, until now, been more market-driven, compared to those in Sweden.

By analyzing and comparing MaaS in Sweden and Finland, we have identified a set of formal and informal institutional arrangements that enable and constrain MaaS development and deployment. The analysis illustrates that macro-level institutions (e.g. public funding of pilots) as well as meso- (e.g. risk aversion among key actors) and micro- (e.g. uncertain market potential) affect the prospect of developing viable MaaS offerings that contribute to societal goals. The analysis furthermore reveals differences (e.g. level of trust among stakeholders) and similarities (e.g. lack of data and standards) across the two cases.

Based on our findings, we suggest both practical and theoretical implications. For instance, on the practical level it is vital to engage a broad set of key stakeholders that have the mandate and discretion to govern MaaS within and beyond their own organizations, in order to promote the development of MaaS. This group should aim to create a concrete yet fluid shared vision for MaaS that tackles sustainability problems on both local and national levels. In order to create a vision that is both aligned with societal goals and with the goals of the key stakeholders in the emerging MaaS ecosystem, the group must include both stakeholders on strategic and operational levels of the transport sector, i.e. a mix of representatives for relevant governmental agencies and new entrants to the transport sector (e.g. MaaS start-ups) as well as incumbent public and private transport service providers. On the theoretical level, as practice-based and structural changes are needed in order to facilitate institutional change, both must be encompassed within applied analytical frameworks, e.g. IRIMS.

Lastly, the cases in this study are situated in a limited context in that they comprise a similar set of institutional arrangements. Further studies are needed in order to examine the influence of institutional arrangements in more divergent settings, for instance in countries where PT cannot serve as the backbone of personal urban mobility.
References


Transport system planning in Helsinki region –dealing with big potentials and big uncertainties

TAPANI TOURU HRT Helsinki Region Transport

Introduction

The Helsinki Region has a long history of regional long-term transport system planning. The planning will guide the regional transport policy and the development of the transport system as a whole. It is a common view of the 14 municipalities, how the region should be developed, created by professionals from HSL, municipalities and state (HSL, 2015).

The planning process has developed into its current form in stages. The recent major development step has been the stronger linkage between the regional land-use, housing, and transport system planning. The Helsinki Region land-use, housing and transport planning (MAL 2019) is fundamental for the region in order to increase its competitiveness and drastically decrease its emissions by affecting to the need and modes of transport. The planning process can be said to be state-of-the-art. However, as uncertainties have increased drastically after the anticipated paradigm shift in mobility has entered the game the planning process needs to be developed too.

Mobility as a service (MaaS) and development of technology hold great potential but also great uncertainties. These uncertainties especially in the operational environment must be taken into consideration in the long-term planning. It is also wise to admit, that there is no accurate information about the speed and magnitude of the anticipated paradigm shift. Thus depending strongly on i.e. certain speed or adaptation of some new solutions means taking big risks. It is important to make resilient plans that can adapt to different futures.

MAL 2019 planning process possess a philosophy of realism and resilience. This means, that in the short span of planning, target year 2030, the focus will be in ”certainly needed measures”. However, in the long term planning, target year 2050, focus will move to a consideration of possible future scenarios. By looking at different scenarios it is still possible to define some measures, that are ”more probably needed” than others. In short term, it is important to keep in mind not to ruin potential for any possible measures in the farther future.

Regional and national targets and goals guide the planning process. Goals set in the MAL 2019 process include ecological, social, and economic sustainability and competitiveness of the region. These goals create the base for planning. Key challenge among the goals is to decrease CO₂ emissions 39 percent from 2005 level by year 2030. This target is set by EU-commission and has been approved by Finnish government. This means that Helsinki region transport emissions need to decrease by 50% by year 2030.

Regional MAL-planning consists of studies, planning, and collaboration to find the best combination of measures to meet the set goals. MaaS, and different services considered to be under the concept, are taken into consideration as measures to meet the goals.

Second chapter presents briefly the methods and material for the paper. Third chapter presents the main findings from the case studies carried out in Helsinki Region. The final chapter presents some conclusions of the main findings.
Methods and Material

Helsinki region transport system planning is based on knowledge acquired from previous planning rounds. The information and contents are updated and added with relevant studies which will be carried out in the next round of planning. Among the studies carried out in MAL 2019 process thus include:

- “New transport technologies and services”
- “Shared mode simulation”
- “Public transport trunk network and land-use”
- “How to reach the target to decrease CO2 emissions”

The above mentioned studies are carried out under the supervision of Helsinki region transport system planning specialists using Emme-transport modeling tools and professional analysis. Key findings from these studies are described in the following chapter.

Review of the Studies

Based on the goals set in global, EU, national, regional and local levels, the key question when carrying out these studies is, how to decrease the CO$_2$ emissions in the most efficient way. This is considered in all studies. The impacts on emissions will be key priority when choosing measures in planning phase. Other set targets are more of a guiding nature. Then as an end result, the plan will consist of measures and policies that lead to less emissions and achieve the goals in the best way possible.

To get an idea, how new transport technologies and services could help the region to meet the goals, a study (HSL 2017) was carried out as part of the process. The key questions of the study were:

- What kind of new technologies and services are out there?
- What kind of potential do they have?
- What kind of risks are included?
- What kind of measures should be implemented as first steps?
- How to manage long term risks?

Fourteen different services or technologies were studied and they were divided into five different categories. The categories in the analysis were sharing, automation, traffic management, home delivery services and motive powers.

To study the concept of sharing, a ride-sharing market model was introduced in the Helsinki region. The study revealed the highest potential for ride-sharing to be in the relatively long trips made from the more densely populated satellite centers outside the metropolitan area. The short average trip distances and good availability of public transport reduce the potential in more urban areas. An interesting result in the model was that 2/3 shared ride users come from public transport. This is a significant risk that needs to be acknowledged as this modal shift can lead to more mileage, hence more emissions, congestion and other harmful effects (HSL 2017).

To study the possible impacts of automation on travel times, a scenario with an increase of 20-30% to road capacity was applied in the Helsinki region morning peak (Fehr & Peers 2017). As a result, it was revealed that the areas that benefit the most from automation are near the arterial roads outside the outer Ring Road (Kehä III), mainly in the areas where the level of public transport is not very high. (HSL 2017)
Some of the new services and technologies add new options to transportation, which facilitates people who do not own cars and reduces the need to own one. Many of the services and technologies also support the more efficient use of resources, such as vehicles and infrastructure. However, some of them may lead to a development that does not meet the society’s objectives, for example increase to the mode share of cars. The most significant risks are related to privately owned automated vehicles, but also the other services based on cars (i.e. car sharing, ride-sharing) may decrease the share of walking, cycling and public transport as was seen in the ride-sharing results.

As a result, suggestions were made based on analysis and impact assessments:

- The impacts of different organizing and business models of ride-sharing need to be evaluated and meaningful services may be advanced by introducing pilot projects or trials. The requirements to infrastructure need to be further evaluated in relation to other modes of transport.
- To make sure that automated vehicles will be shared it is important to focus on the right models to achieve this. The trials should be connected to ride-sharing trials. The impacts of automation on urban sprawl need more attention.
- Dynamic pricing is recommended as a tool to manage the externalities of transport and to address many of the threats related to the new services and technologies.
- The new formats of cycling, such as bike-sharing and electric bikes, are advanced by investing in cycling infrastructure and expanding the city-bike system.
- Expansion of the charging network of electric cars is also recommended.

Another study done in the Helsinki region was carried out by OECD/ITF. The study of “Shared mobility – Simulations for Helsinki” (2017) answered to a question “what if different shares of current mobility would be done by shared vehicles”. The entire mobility of the Helsinki Metropolitan Area was simulated for one working day, including the current modes and different adoption rates of the new shared services. The simulation provided a detailed array of indicators that allowed the measurement of:

- Impacts on the city and the transportation system, such as decreases in CO₂ emissions, parking space required, car use, congestion, changes to accessibility and the extent of modal shift.
- New shared services performance, both from a user perspective (travel times, waiting times, access times, number of transfers) and operator or production side (number of vehicles, occupancy, depot location and sizes, costs).

Nine different scenarios were preliminarily studied. Out of those most influential is a scenario, where all trips made by private cars are substituted by shared mobility and public transport kept as it is. Reduction in vehicle kms, CO₂ emissions and congestion compared to baseline is more than 30%.

However, Helsinki region was interested in studying more in-depth scenarios that could describe the situation after first steps of implementation. The results show that public transport is an important part of transport system. These new modes would give benefits, compared to current system, in areas, where there is currently poor public transport as a result of low population density.

The findings from the OECD/ITF study show that compared to current situation, it is very difficult to improve accessibility and thus get benefits from areas that have good public transport service. In conclusion, public transport seems to be the correct mode for masses in these areas.

Another study was carried out to find out, how land use and public transport should be developed together. In the study, accessibility with sustainable modes was compared with land use density. The study showed
that there is a lack of accessibility in the municipal centers outside of the metropolitan core. These are areas, where it is not economically viable to run efficient public transport service but still have some population densifications. Another key finding from the study is that in the metropolitan core, the accessibility enables still much more densifying, compared to preliminary land use data collected in MAL 2019. These results will guide further MAL 2019 planning. Densifying land use in existing rail corridors is one key starting point as this has good impacts on set goals.

The land-use data collected from municipalities show clearly, that the idea of densifying in rail corridors is well adopted. By the year 2050, approximately 80% of the population in the region is located in 30 biggest centers that are also trunk network node points. This kind of densification creates good potential for better public transport and enables walking and cycling. On the other hand, this densification means that space will be altogether scarcer. In addition, it is ever more important to zoom the focus on the attractiveness of city centers and local emissions. This means, that modes that have low space efficiency and create local emissions, should not be promoted in city centers. The extra space needed for cycling network, attractive pedestrian areas and for new kiss-and-ride services that will decrease emissions can be obtained from parking. This will be made possible for example with shared mobility modes, studied in the OECD/ITF simulation that decrease the need for car ownership. The most efficient all around tool for decreasing car usage is pricing.

There has been substantial amount of discussion about climate change. However, the actions which have an effect on climate change have not been as substantial. The study about “measures needed to meet the climate targets by year 2030” (HSL 2017) was done to obtain a clear understanding of the scale of measures needed. The results show that no single measure tested was able to decrease emissions enough. A combination of congestion charging, increase of parking costs, drastic increase of electric vehicles, the increase of public transport and cycling, and improvement of heavy transport fuel efficiency could altogether lower the emissions enough. The challenge is how to enable these measures now. The positive notion however is that the needed measures already exist.

Discussion and Conclusion

The results of MAL 2019 planning show that there is a need for strong public transport and i.e. good cycling network in any given future of mobility. According to MAL 2019 philosophy, investments in node point improvement and in public transport trunk and bicycle network are surely effective. How large these investments should be is another question entirely. Nevertheless, there recognizable risk, that insufficient investment to public transport can lead to less resource efficient travel patterns. This in turn could lead to undesired land use development. Hence, it is necessary to keep investing to public transport in order to keep it attractive to the general public, maintain functionality of the transport system and control emissions. Development of public transport oriented land use simultaneously improves possibilities to use bicycle or walk on daily trips.

From the transport system planning perspective, which is guided by goals of sustainability, it is clear that MaaS or any other transport trend should not compete with traditional sustainable means of mobility, as long as they do not prove to deliver better results. Competition can deteriorate the current transport system and lead to undesired impacts. If the big volumes using public transport currently would start choosing undesired and less sustainable travel patterns the impacts would be very negative.
Instead of competing with public transport and other sustainable modes of transport, the focus for developing MaaS and other new technologies and services should be clearly in developing them first as feeder services. This should be done especially for areas that currently lack services, i.e. the outerskirts of Helsinki region. This is of course a challenge from business perspective, but from societal perspective, that would be the right thing to do. At least in short term. Making it attractive to use sustainable modes of transport in areas where private car is the only real option currently would make a big difference. It is most important that people learn new sustainable ways for their mobility. This change in attitudes is much needed in order for the MaaS services to succeed. While Maas has a novelty value, it can make the change in attitudes happen. Nevertheless it needs to be stressed, that the new travel behavior patterns should take us towards more sustainable societies. Decisions of development and regulation should be based on sustainability, not for example freedom of movement. The problems that high adaptation of private cars has caused must have taught us something.

The reports of the studies mentioned in this paper can be found (in finnish) from https://www.hsl.fi/mal/julkaisut
SCIENTIFIC 8

Roadmap for a paradigm shift
Challenges in the Paradigm Change from Mobility as a Self-service to Mobility as a Service

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Abstract

The predominant paradigm of everyday mobility in Finland is mobility as a self-service where most of the mobility needs are taken care with passenger cars. The ‘Mobility as a Service’ (MaaS) model is a new paradigm that challenges the current mobility practises. The purpose of this paper is to describe the current state of mobility and analyse the potential and challenges of MaaS against current situation in demographics, mobility and mobility related consumption in Finland. It would require a big shift in the current mobility practises for MaaS to become mainstream. In this paper, on one hand potential and one the other more challenging customer segments are recognised and the possibilities of MaaS to address these are discussed.

1. Introduction

In the developed countries, automobiles has grown to be dominant mode of transport since their launch in late 1800s. During the 20th century, the number of passenger cars as well as passenger car mileage grew to support the lifestyles of the modern society. Together with more and more cars and kilometres travelled, problems associated with cars has increased to a state where options for this mode are asked for more and more. Could we own and use cars less, yet still fulfil our daily mobility needs? As one suggested model, Mobility as a Service, MaaS, offers an option by aiming to make travelling with different modes easy and fluent. This way MaaS could compete with the current car based system. As Heikkilä (2014) in one of the first studies on MaaS describes, Mobility as a Service can be seen as a system, where mobility operators provide a comprehensive range of mobility services to customers. MaaS can also be seen as a solution for more sustainable mobility, especially as it could replace car-based mobility. In a European MaaS study, MaaSiFiE, Mobility as a Service is defined as “multimodal and sustainable mobility services addressing customers’ transport needs by integrating planning and payment on a one-stop-shop principle” (König et al. 2016).

The aim of this paper is to describe the current state of mobility and analyse the potential and challenges of MaaS against current situation in demographics, mobility and mobility related consumption in Finland. The following questions are set: where is the potential and challenges of MaaS in Finland in demographic and geographic sense and in terms of mobility practises and consumption, and how can the MaaS scheme address this potential and challenges. The current transport system and everyday mobility in Finland can be depicted as mobility as a self-service as it is illustrated by passenger car dominance. In the most recent national travel survey conducted in 2010-2011, passenger cars had the share of 58% of the trips and 72% of the kilometres travelled (Finnish Transport Agency 2017). In this study, the statistics related to population, mobility, and consumption in Finland are analysed and the current mobility practises are set against the MaaS concept to study its potential and challenges in Finland. The motivation to this approach (i.e. to analyse the potential and challenges using different statistics) is that the past and current MaaS pilots and schemes nor previous research have not addressed this sufficiently. This paper strives to contribute to recognising how MaaS schemes could reflect the Finnish demographics, mobility practises and consumption patterns.
Since Mobility as a Service is a new concept there has not yet been many studies published on MaaS at this point. However, the interest towards MaaS is high, there is active research ongoing, and the number of scientific publications on MaaS is rapidly increasing (Utriainen and Pöllänen 2017). Only a few publications can be recognised where the potential and challenges of MaaS have been studied, and typically without exploiting statistics similar to this paper. One of these is the study by Transport Systems Catapult (2016) on the opportunity for Mobility as a Service in the UK with a focus on the future role of transport policy. Kamargianni et al. (2015) analysed the potential of MaaS in the context of a large city as they identified supply and demand of transport services London, UK, and presented a MaaS-London concept for the future. Additionally, related to MaaS-London concept, Mayas & Kamargianni (2017) carried out stated preference (SP) study to understand people’s mobility choices under MaaS.

In previous studies, the potential of MaaS has mostly been discussed regarding the future roles of different transport modes and services. For instance, Becker et al. (2017a, 2017b) studied car-sharing schemes in Switzerland and found that currently the most potential user group in car-sharing is young and highly educated people. Reflecting different aspects of the potential and challenges of MaaS, Giesecke et al. (2016) presented four key conceptual issues of MaaS, namely 1) nature of travel (e.g. trip purpose, trip length, mode, and means), 2) interoperability, 3) end-user behaviour related to e.g. different user groups, gender issues, and aging, and 4) sustainability. MaaS trials and models are an alternative way to assess the potential and challenges of MaaS. Strömberg et al. (2016) studied a trial concept for changing the travel behaviour. Karlsson et al. (2016) studied how UbiGo trial in Gothenburg, Sweden responded to user needs, while Kamau et al. (2017) tested a demand responsive MaaS model in Dhaka, Bangladesh, targeting to reduce passengers’ waiting time.

2. Data and methods

To analyse the paradigm changes needed for MaaS to challenge the current mobility practises in Finland, MaaS is described based on previous studies in section 3. Based on a literature study, the MaaS concept is described. Relevant literature was recognised using the phrase “Mobility as a service” in ScienceDirect search. Additionally research reports on MaaS were recognised and put to use in the literature study.

Data on population from Statistics Finland is exploited to describe background information for understanding mobility in Finland. To depict the current mobility practises, data from the last available Finnish national travel survey from years 2010-2011 is presented. Data from Statistics Finland on household consumption describes the economic perspective and current household spending on mobility. This analysis is presented in section 4. Finally, in section 5, the discussion and in section 6, the conclusions are presented.

3. The concept Mobility as a Service

As MaaS has become a general term to describe many different things, there is no one definition of MaaS (Hoadley 2017). Yet, in the different definitions made and different MaaS services launched, there are often many common attributes. The Transport Systems Catapult (2016) defines MaaS as “using a digital interface to source and manage the provision of a transport related service(s) which meets the mobility requirements of a customer”. The transport services can be whatever the customer prefers, private or public, and the markets will shape what will be available (Transport Systems Catapult 2016). Additionally shared transport services, being somewhere between private and public, can be on the service mix of MaaS, as well as e.g. parking services. In fact, König et al. (2016) see shared mobility together with booking/ticketing and
multimodal traveller information as the three key concepts for deployment of MaaS concepts. MaaS also offers its customers the ability to take part in the sharing economy by sharing their transport assets e.g. car or motorcycle (Transport Systems Catapult 2016). MaaS seeks to offer a personalised mobility service to meet the travellers’ needs (Hoadley 2017).

Transport Systems Catapult (2016) states that there will be no one MaaS model that fits all. This holds both from the business perspective, as there is a great amount of different stakeholders, which make the models probably different, as well as from the user perspective as the service should align with the lifestyles of different customers.

In the core of the MaaS business model is the servitisation-based value proposition, the bundle of different transport services which is created by the MaaS operator (service provider) to fulfil the customer needs. The bundle can also be made for a larger group than just one person, e.g. MaaS package can be a solution for household’s mobility, fulfilling e.g. not only adults’, but also children’s mobility needs. Another important point in the MaaS business model is that the MaaS operator helps the transport operators improve their service by sharing the data on customers’ mobility needs. (Transport Systems Catapult 2016) The ownership of data, which can be considered as a very valuable asset, is an important question. For example, Melis et al. (2016) raise the question if private companies instead of public administration bring uncertainty in data collection and usage in a MaaS scheme.

As MaaS offers the policy makers an opportunity to achieve changes in travel behaviour and to manage travel demand, the question should be stated, what type of MaaS do the policy makers want to see grow. It is important to acknowledge that in addition to positive outcomes from transport policy point of view, MaaS could also lead to a mode-shift away from public transport and increasing number of journeys. (Transport Systems Catapult 2016) If MaaS offers improved individual mobility, this could mean more traffic and eventually more congestion (Rantasila 2016). People could e.g. replace conventional timetabled public transport with flexible car-sharing services during the peak hours (Henscher 2017).

Five key capabilities related to MaaS value proposition are journey planning, easy transactions, flexible payment, dynamic journey management, and personalised service (Transport Systems Catapult 2016). MaaS can offer value especially in multimodal journeys, where e.g. flexible payment, easy transactions and dynamic journey management are not that developed. It is noteworthy that also personalised services are much missing in today’s mobility markets. Table 1 presents a compilation of the strengths and weaknesses in the current mobility system and MaaS.
Table 1. Strengths (+) and weaknesses (−) in the current mobility system and MaaS.

<table>
<thead>
<tr>
<th>Current mobility system</th>
<th>MaaS</th>
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</thead>
<tbody>
<tr>
<td>+ Routines and lock-in in the current practises (car ownership, car-based land use and transport planning)</td>
<td>+ People are more and more service-oriented, there is potential for greater adoption of new mobility models, maybe leading to reduced car ownership (Transport Systems Catapult 2016)</td>
</tr>
<tr>
<td>+ Easiness and convenience of the private car</td>
<td>+ Integrated mobility services can be easy-to-use and make public transport more tempting</td>
</tr>
<tr>
<td>+ Mature and familiar technology and user interface of passenger cars</td>
<td>+ Technology develops rapidly and more and more transport data is available (Transport Systems Catapult 2016)</td>
</tr>
<tr>
<td>- High costs associated with passenger car ownership (purchase, time based fees e.g. taxes and insurance) and use -&gt;</td>
<td>+ Highly automated vehicles can be integrated into MaaS offering (Transport Systems Catapult 2016)</td>
</tr>
<tr>
<td>+ -&gt; resulting also in using own car (if there is one) when it's costs are already payed for to great extent, making car use more tempting than using other modes in many cases</td>
<td>- Low customer awareness of the MaaS model, no full scale services available</td>
</tr>
<tr>
<td>- Far from sustainable mobility</td>
<td>- Difficult to break the lock-ins - differences in entering the market as a new concept</td>
</tr>
<tr>
<td>- The increasing challenges with cars in urban areas (lack of parking places, high parking costs, car restricted areas, road fees)</td>
<td>- People are not aware of their transport related costs and cost structure, especially car ownership and use</td>
</tr>
</tbody>
</table>

It may be challenging for the MaaS operators to introduce attractive value offerings for a significant proportion of the consumer market. However, the size of the mobility market and the diversified mobility needs offer potential for MaaS model. As the early adopters, new millennials are likely MaaS consumers. (Transport Systems Catapult 2016) Men and high-income groups are estimated to have a positive attitude towards new technology (El Zarwi et al. 2017), which could also be a supporting issue for MaaS. One of the potential key services in MaaS, car sharing, is analysed to appeal to social activists, environmental protectors, innovators, economizers and practical travellers (Burkhardt & Millard-Bal 2006). It is expected that social motivations for joining the sharing economy are more dominant amongst older as compared to younger people, and women show higher environmental motivations for joining the sharing economy compared to men (Böcker & Meelen 2017).

The analysis by Transport Systems Catapult (2016) suggest two potential growth paths for MaaS markets. The first is a market, where MaaS operator offer services focused on cars, e.g. taxi, carshare and rideshare. The second market is a truly multimodal service including before-mentioned services as well as passenger service vehicles and traditional public transport. A high growth market could lead to greater levels of multimodal journeys, and possibly as shared mobility reaches a critical mass multi-vehicle households would begin to reduce the number of cars they own and other households could travel solely using MaaS. (Transport Systems Catapult 2016)

In our analysis regarding Finland, presented in the next sections, the MaaS model considered is a truly multimodal service as described above. We recognise that the services are expected to differ between urban and rural areas, between cities of different sizes and depending on the urban structure, e.g. city centre vs. suburban area. There are great differences between cities in Europe and the USA in terms of population density and the non-auto and automobile dependent planning which reflect to the viable modes in different cities (Klinger et al. 2013). From this point of view it is expected that the greatest MaaS potential is in the
biggest cities offering widest selection of different transport modes and services whereas MaaS schemes in rural areas can be very limited in terms of different services bundled. The services in rural areas may need more public support whereas the areas with large transport demand can support commercial MaaS schemes. A MaaS pilot in Gothenburg, Sweden, proved that public support is vital for a successful and sustained service (Karlsson et al. 2016). In less populated rural areas MaaS can contribute to the livelihood of the area with lower costs with the help of more responsive transport services (Rantasila 2016).

4. Demographics, mobility practices and households’ consumption on mobility in Finland

The demographics, current state of mobility and consumption on mobility – and the related challenges in changing the mobility paradigm – are analysed in Finland, a Nordic country with a relatively small population, 5.5 million in 2017, especially compared to the large land area, resulting in a population density of 18.1 inhabitants per square kilometre (Statistics Finland 2017e). There is only one larger metropolitan area, Helsinki with 1.5 million inhabitants, and additionally six cities with above hundred thousand inhabitants in Finland (Statistics Finland 2017d). In these cities and the surrounding urban areas, the population density is naturally significantly higher than the Finnish average.

As discussed earlier, the greatest potential for MaaS is seen in larger cities, which means that Helsinki metropolitan area is the most obvious MaaS market in Finland. MaaS Global started with its Whim service in Helsinki, but there have also been MaaS trials in smaller cities in Finland, such as in Seinäjoki (62,000 inhabitants) and even in Ylläs which a tourist attraction in Kolari with 3,800 inhabitants (Statistics Finland 2017d) in Lapland (Tekes 2017). In the case of Ylläs, the MaaS service included journey planning and payment using an app from train station and airport to Ylläs, and a skibus or taxi to travel with to ski slopes (Tekes 2017). In the case of Whim in Helsinki, the service includes regional public transport, taxis, and rental cars bundled to different monthly packages, and in Seinäjoki, the service includes local public transport, demand-responsive bus services and taxis (Tekes 2017). These examples depict how MaaS services can be tailored to specific circumstances.

Figure 1 presents demographics in Finland in terms of urban-rural classification. The majority of population (3.8 million people, 69.2%) lives in urban areas. From these areas, inner urban area with 1.8 million inhabitants has the highest population density, and thus the area of greatest MaaS potential as it offers the widest selection of different mobility services, including public transport typically with high service level. In the inner urban core, there is less need to own a car and usually the space and costs for parking are limiting car ownership and use. From the rural areas, rural heartland areas and sparsely populated rural areas have the smallest potential when considering the population density and the services that can be offered to a limited amount of people with reasonable prices. In these rural areas, economies of scale is difficult to reach and the potential services in MaaS could be especially in shared mobility as there is very little, if any, public transport available.
The urban areas in Finland are mainly in the southern and western parts of the country, see figure 2. The inner and outer urban areas are a very small portion of the land area, but together with the peri-urban areas, larger areas and transport corridors can be seen to offer a larger potential for MaaS schemes in terms of geographical area. The potential in these areas relate to the larger commuting areas especially in the southern and western parts of the country, which is why a MaaS scheme especially in these areas should include as a key feature services tailored for commuting trips. Majority of Finland is sparsely populated rural area. Considering future demographic development, the urban areas, especially the largest urban regions, are expected to grow whereas the population in rural areas is expected to decrease as a result of internal migration, i.e. continuing urbanisation, and differences in birth and mortality rates.

**Figure 1.** The share of population in different areas in the end of 2015 in Finland. (Statistics Finland 2017c)
In addition to the total amount of people and their residential areas, population’s age distribution is important when considering the mobility practises and the potential and challenges of MaaS. From general mobility point of view and by using age group division, we can distinguish children and senior citizens that are outside the labour markets, young adults studying and entering the working life, and the working-age population. Considering differences in mobility, even more detailed groups could be recognised, such as children before and in school age as well as younger and older adults and senior citizens. To keep this analysis more compact, we discuss four age groups presented in table 2. The urban-rural classification is presented in combined groups of urban and rural population.
### Table 2. Population in different areas and in different age groups in the end of year 2015 in Finland. (Statistics Finland 2017c)

<table>
<thead>
<tr>
<th>Amount of people</th>
<th>under 15 years old</th>
<th>15 - 24 years old</th>
<th>25 - 64 years old</th>
<th>65+ years old</th>
<th>Total population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban areas</td>
<td>625,160</td>
<td>479,126</td>
<td>1,991,913</td>
<td>701,779</td>
<td>3,797,978</td>
</tr>
<tr>
<td>Rural areas</td>
<td>261,857</td>
<td>150,913</td>
<td>791,182</td>
<td>413,658</td>
<td>1,617,610</td>
</tr>
<tr>
<td>Unknown coordinates</td>
<td>9,006</td>
<td>10,348</td>
<td>44,700</td>
<td>7,666</td>
<td>71,720</td>
</tr>
<tr>
<td>Total</td>
<td>896,023</td>
<td>640,387</td>
<td>2,827,795</td>
<td>1,123,103</td>
<td>5,487,308</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Share of total population</th>
<th>under 15 years old</th>
<th>15 - 24 years old</th>
<th>25 - 64 years old</th>
<th>65+ years old</th>
<th>Total population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban areas</td>
<td>11.4 %</td>
<td>8.7 %</td>
<td>36.3 %</td>
<td>12.8 %</td>
<td>69.2 %</td>
</tr>
<tr>
<td>Rural areas</td>
<td>4.8 %</td>
<td>2.8 %</td>
<td>14.4 %</td>
<td>7.5 %</td>
<td>29.5 %</td>
</tr>
<tr>
<td>Unknown coordinates</td>
<td>0.2 %</td>
<td>0.2 %</td>
<td>0.8 %</td>
<td>0.1 %</td>
<td>1.3 %</td>
</tr>
<tr>
<td>Total</td>
<td>16.3 %</td>
<td>11.7 %</td>
<td>51.5 %</td>
<td>20.5 %</td>
<td>100.0 %</td>
</tr>
</tbody>
</table>

From the figures in the table above, it can be stated that adults in the urban areas (2.0 million inhabitants, 36% of the total population) present the largest MaaS market. The challenge of MaaS related to this demographic group is that the adults are likely to be relatively locked to their mobility practises. As a contrast to this group, the young, aged 15 to 24, are especially interesting from MaaS point of view as people in this group do not own cars to a high degree, and in Helsinki for instance, the 18-years-olds are getting driving licences much less than before and compared to other areas in Finland. In Helsinki, only 33% acquired the driver’s license when turning 18 whereas the share was 75% in rural areas in 2012 (Löytty 2014). Every year about 60,000 Finns reach the age of 18 and make decisions on whether to get the driving licence and a private car or not. Of these youngsters, two thirds live in urban areas and one third in rural areas (Statistics Finland 2017c).

From future point of view, it is worth to note that the greatest shift in population is forecasted to be in the amount of senior citizens. Already today, as depicted in table 2, the senior population is the second greatest group and its relative share is especially high in rural areas. The amount of people over 75 years of age will increase from the current 500,000 to over 800,000 in less than 15 years, by 2030 (Statistics Finland 2017f). In all the other age groups, the population is expected to stay roughly at the same level, see figure 3. From MaaS point of view, it would be very interesting to consider this demographic development by thinking how the MaaS scheme could best serve this growing population. As people get older, they may prefer services in many occasions, e.g. as driving a car may get more difficult. Easy to use and access services, both physically and virtually – and maybe assisted –, would benefit especially this group.
The shares of trips done with different modes in different age groups are presented in table 3. The youngest people, under 15 years old, do most of their trips as car passengers, pedestrians and cyclists. It’s worth to note that many of children’s trips are done together with their parents so the MaaS solution should acknowledge this and for instance offer a service pack including services for the whole family. For children under 15 years of age, MaaS scheme could especially include services that offer the possibility to make trips by passenger car or a similar service in terms of service level, having the possibility to travel flexibly to the desired place. Almost half of the trips is done by walking and cycling, and considering this, the MaaS scheme could include bikes (e.g. shared bikes, city bikes or rental bikes), encouraging the kids to cycle even more, maybe replacing some the current car trips to be made by bike. Also walking could be encouraged by offering different assisting equipment, e.g. hoverboards, as a part of the MaaS scheme. As described earlier, the 15 - 24 aged are in the transition phase where the main mode is already passenger car as driver (29%), but not as clearly as for the older generations who do more than 50% of their trips as car drivers. Walking has an important role for every age group but it is worth to remember that these trips are short, thus representing only a small portion of the passenger mileage. In cycling, we can recognise a diminishing role the older generations are. Similar to walking, cycling trips are short in general, and have a low possibility to be replaced by transport services. The share of public transport is the highest for people aged 15 - 24, which also indicates high potential from the MaaS perspective as the youngsters are already more familiar to using mobility services compared to other age groups.

Figure 3. The population forecast for different age groups to year 2030 in Finland (Statistics Finland 2017f).
Table 3. The share of trips done with different transport modes in different age groups in Finland in 2010–2011. (Data from Finnish Transport Agency 2017) * Note that the figures have not been weighted and ‘All age groups’ does not reflect the share of population in the different age groups.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Walking</th>
<th>Cycling</th>
<th>Passenger car as driver</th>
<th>Passenger car as passenger</th>
<th>Public transport</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>under 15 years</td>
<td>27.5 %</td>
<td>21.0 %</td>
<td>0.4 %</td>
<td>38.6 %</td>
<td>8.7 %</td>
<td>3.8 %</td>
<td>100.0%</td>
</tr>
<tr>
<td>15 - 24 years</td>
<td>24.2 %</td>
<td>8.9 %</td>
<td>28.7 %</td>
<td>18.1 %</td>
<td>13.3 %</td>
<td>6.8 %</td>
<td>100.0%</td>
</tr>
<tr>
<td>25 - 64 years</td>
<td>17.2 %</td>
<td>6.0 %</td>
<td>55.9 %</td>
<td>9.5 %</td>
<td>6.2 %</td>
<td>6.8 %</td>
<td>100.0%</td>
</tr>
<tr>
<td>65+ years</td>
<td>25.7 %</td>
<td>5.1 %</td>
<td>25.7 %</td>
<td>9.9 %</td>
<td>4.6 %</td>
<td>5.3 %</td>
<td>100.0%</td>
</tr>
<tr>
<td>All age groups*</td>
<td>20.3 %</td>
<td>7.6 %</td>
<td>46.9 %</td>
<td>13.2 %</td>
<td>6.9 %</td>
<td>5.1 %</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Compared to the previous table that depicts the share of trips in Finland, the passenger mileage is even more car dominant reflecting longer trips done by car than by walking or by bike. In figure 4, the passenger mileage is presented in different areas and by different transport modes in Finland. It can be seen that the smallest passenger car mileage is clearly in inner urban area which is also the only area with metro and tram available. The mileage grows in outer and peri-urban areas as a result of sparser population and longer distances to attractions such as workplaces and commercial activities. The highest mileage is in sparsely populated rural areas where the distances are usually long and passenger car the most viable option for travelling. From MaaS point of view, the difference of passenger car driver and passenger is that the drivers are less eager to change mode and give up driving compared to passengers who are already more familiar to the role of passenger. Looking at this from a household perspective it is usually that the passengers in passenger cars are from the same household as the driver. This presents at the same time a challenge and a potential for MaaS as the MaaS scheme for a household could change the mobility practises for the whole household to other modes than passenger cars, or at least the person(s) usually being the car passenger(s) could adopt using different services in the role of a passenger. Yet, it requires a big shift, and is this a major challenge to overcome for MaaS. It has been explicitly noted, that drivers are very attached to using their vehicles (Tertoolen et al. 1998).

Figure 4. Average passenger mileage by mode in different types of urban and rural areas in Finland in 2010-2011. (Finnish Transport Agency 2014)
The Finnish population of 5.5 million inhabitants had 2.65 million passenger cars in use in the end of 2016 (Statistics Finland 2017a), resulting in 482 cars per 1,000 inhabitants. As there were 2.56 million households in Finland in 2012, it could be interpreted that approximately every household has a passenger car in use. Yet, this is not the case, as there is a great amount of multi-car households. 74% of Finnish households had car use: 51% had one car, 20% two cars and 4% three or more cars in 2012. (Statistics Finland 2012) There is a clear difference in the amount of cars in use in households of different sizes with almost half of the one-person households not having a car in use. Over half of four+-person households have more than one car in use, see figure 5. Considering this from MaaS point of view, there is clear potential related to the households not owning a car. The challenge is to make the MaaS scheme tempting for the households with one or more cars. For the multicar-households, MaaS can offer the possibility to give up car ownership, even if not totally, replacing the second or third car with mobility services.

![Figure 5. The number of passenger cars in use in households of different sizes in Finland in 2012. (Statistics Finland 2012)](image)

Table 4 presents the number of cars in use for different age groups. These figures present that the households with children under 15 years of age are the most car-intensive as there is only 5% with no car in use and 52% with two or more cars. Most one-car respondents were the 65+ years old in the 2010-2011 travel survey. With the largest no-car shares, the senior citizens and the 15 to 24 years old are very potential from MaaS point of view. People in these age groups live typically in small households.

Table 4. The share of cars in use (no car, 1 car, 2 cars or more) in different age groups in Finland in 2010–2011. (Data from Finnish Transport Agency 2017) * Note that the figures have not been weighted and ‘All age groups’ does not reflect the share of population in the different age groups.

<table>
<thead>
<tr>
<th></th>
<th>under 15 years old</th>
<th>15 - 24 years old</th>
<th>25 - 64 years old</th>
<th>65+ years old</th>
<th>All age groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>No car</td>
<td>5%</td>
<td>19%</td>
<td>12%</td>
<td>22%</td>
<td>14%</td>
</tr>
<tr>
<td>1 car</td>
<td>43%</td>
<td>37%</td>
<td>51%</td>
<td>67%</td>
<td>52%</td>
</tr>
<tr>
<td>2 or more cars</td>
<td>52%</td>
<td>43%</td>
<td>37%</td>
<td>11%</td>
<td>33%</td>
</tr>
</tbody>
</table>
Table 5 presents car ownership in one- and two-person households. These households represent 40% and 35% of Finnish households, respectively, and their shares are growing (Statistics Finland 2012). More than half of Finns live in these small households and the average size of household is slightly above 2 family members (Statistics Finland 2012). In the table, there can be seen a clear rise in car ownership in the older age groups between 2006 and 2012 whereas in the two youngest age groups car ownership has levelled off and in fact decreased in 2 of the 4 cases. As the number of small households is expected to grow the most, this means a potential from MaaS perspective as these households are often carless compared to 2+-person-households.

**Table 5.** The share of households having car in use in one and two person households in 2006 and 2012 in Finland. (Statistics Finland 2012)

<table>
<thead>
<tr>
<th>Age group</th>
<th>One-person households</th>
<th>Two-person households</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>year 2006</td>
<td>year 2012</td>
</tr>
<tr>
<td>16 - 34</td>
<td>46%</td>
<td>47%</td>
</tr>
<tr>
<td>35 - 44</td>
<td>69%</td>
<td>66%</td>
</tr>
<tr>
<td>45 - 54</td>
<td>55%</td>
<td>64%</td>
</tr>
<tr>
<td>55 - 64</td>
<td>55%</td>
<td>67%</td>
</tr>
<tr>
<td>65 - 74</td>
<td>44%</td>
<td>62%</td>
</tr>
<tr>
<td>75 -</td>
<td>18%</td>
<td>34%</td>
</tr>
<tr>
<td>All age groups</td>
<td>45%</td>
<td>54%</td>
</tr>
</tbody>
</table>

A recent study in Finland shows that the share of households owning a car has been stable in past years, but as the number of households is increasing, there were 70,000 more households in 2016 compared to 2012, the number of households owning a car is still rising. Also the share of households owning other motorised vehicles has been stable during 2012 and 2016. The study also presented that 89% of the households have a bicycles, reflecting bikes being the best available vehicle for the Finnish population. (Statistics Finland 2016)

In 2012, 7% of the households had a moped and 10 % a motorcycle in use (Statistics Finland 2017b).

Of the 19.0 billion euros that Finnish households consumed on mobility in 2012, including vehicle purchase and their use as well as purchase of different transport services, 15.1 billion was linked to passenger cars and their use. On average, the households used 6,110 euros on transport, i.e. 509 euros a month. In Finland, the share of expenditure on transport was 17% of all household consumption. The households spent more money only on housing and energy, i.e. transport and mobility are major subjects in households’ consumption. (Statistics Finland 2017b) The Finnish figures can be compared to the UK, where the household spending on transport was approximately £300/month (€330/month at current exchange rates (ECB 2017)), representing 14% of household consumption, and transport being in fact the biggest category of household expenditure in UK in 2014 (Office for National Statistics 2015).

As can be seen from the previous figures, transport and mobility market has a big potential for MaaS operators. MaaS could cause a redistribution of the current consumption on mobility or it could generate new expenditure from consumers that demand new mobility services based on their needs (Transport Systems Catapult 2016). With the 509 euros a month in mobility in the average Finnish household, there is a great economic interest to use this money wisely. For Finland, the transport’s share of consumption is high in international comparison (Kauppila 2011), reflecting long distances, automobile based mobility and perhaps also defects in transport services, which MaaS could for one be improving.
In a recent survey, only 16 per cent of Finns had heard of MaaS. However, in the same survey, 80 per cent of respondents saw it necessary to able to travel the whole trip chain with the same ticket, which indicates the need for MaaS solutions. Over half of respondents under 30 years of age were willing to give up car ownership if transport services would be adequate. The willingness to pay for a monthly package covering all the mobility needs was relatively low as the respondents were willing to pay less than 150 euros a month on the average, although 10% of the respondents were willing to pay more than 400 euros. (Solita 2017) From MaaS perspective, this 10% is a very lucrative market segment. Additionally, the young willing to abstain car ownership, is a very potential customer group.

Table 6 presents the consumption of different types of households in Finland. Great variety can be seen in consumption in terms of where different households spent their money and how much was spent. From the average share of 17.1% spent on transport and car’s average share of 86.8% of transport consumption, the lowest shares are 11.5% spent on transport in senior citizen households and 76.7% spent on cars in non-senior one-person households. The last-mentioned reflects the low car ownership rate in one-person households whereas low transport spending of senior citizen is likely to reflect lower mobility. Contrarily, the highest shares are non-senior couples without children, who spent 20.2 % of their consumption on transport and two-parent families with children that spent 90.3% of transport consumption on cars, again reflecting high car ownership and car-based mobility. (Statistics Finland 2017b) In terms of high consumption, this would be a very interesting customer segment for MaaS operators, but at the same time challenging as the mobility patterns in these households are typically very bind to car use.

Table 6. Different types of households’ consumption on transport and cars in euros in Finland in 2012. (Statistics Finland 2017b)

<table>
<thead>
<tr>
<th></th>
<th>All households</th>
<th>One-person household, under 65 of age</th>
<th>Couple without children, both under 65 of age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of households</td>
<td>2,595,000</td>
<td>686,574</td>
<td>481,788</td>
</tr>
<tr>
<td>Household’s disposable income</td>
<td>42,103</td>
<td>24,550</td>
<td>48,809</td>
</tr>
<tr>
<td>Household’s total consumption</td>
<td>35,770</td>
<td>23,573</td>
<td>42,595</td>
</tr>
<tr>
<td>Household’s total consumption on transport</td>
<td>6,110</td>
<td>3,405</td>
<td>8,613</td>
</tr>
<tr>
<td>Transport’s share of consumption</td>
<td>17.1%</td>
<td>14.4%</td>
<td>20.2%</td>
</tr>
</tbody>
</table>

Consumption on cars and other motorised vehicles

<table>
<thead>
<tr>
<th></th>
<th>All households</th>
<th>One-person household, under 65 of age</th>
<th>Couple without children, both under 65 of age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchasing of cars</td>
<td>2,219</td>
<td>896</td>
<td>3,293</td>
</tr>
<tr>
<td>Fuels and lubricants</td>
<td>1,420</td>
<td>835</td>
<td>1,985</td>
</tr>
<tr>
<td>Maintenance and repair</td>
<td>834</td>
<td>498</td>
<td>962</td>
</tr>
<tr>
<td>Spare parts and accessories</td>
<td>268</td>
<td>126</td>
<td>587</td>
</tr>
<tr>
<td>Other services</td>
<td>209</td>
<td>124</td>
<td>236</td>
</tr>
<tr>
<td>Vehicle provided as an employee benefit</td>
<td>182</td>
<td>94</td>
<td>216</td>
</tr>
<tr>
<td>Purchase of motorcycles, snowmobiles etc.</td>
<td>170</td>
<td>40</td>
<td>301</td>
</tr>
<tr>
<td>Total</td>
<td>5,302</td>
<td>2,613</td>
<td>7,580</td>
</tr>
<tr>
<td>Car’s share of consumption on transport</td>
<td>86.8%</td>
<td>76.7%</td>
<td>88.0%</td>
</tr>
</tbody>
</table>
As e.g. consumption on fuels and lubricants and maintenance and repair of all vehicles (i.e. also other vehicles than cars) are in the same category in the statistics, the figures in table 6 include also some spending e.g. on motorcycles and snowmobiles. Considering the Finnish context of car dominance, the spending on vehicle use is in practice directed on cars. To compare the situation in Finland with UK, transport expenditure in UK was in 2014 more oriented (22 % in UK vs. 13% in Finland) to transport services, which include mainly travel fares (Office for National Statistics 2015).

The consumption can also be categorised based on the living environment. Urban, semi urban and rural municipalities depict the differences between residential environments and result in differences in transport consumption. The clearest difference in between the smaller amount and share of consumption on cars in urban areas, see table 7. Vehicles provided as an employee benefit are also much more common in urban areas in comparison to other areas. In rural areas, the amount and share of money spent on transport is clearly the highest. The most evident difference in consumption on fuels (and lubricants) which connect to the higher mileage in the rural areas.
Table 7. Urban, semi-urban and rural households’ consumption on transport and cars in euros in Finland in 2012. (Statistics Finland 2017b)

<table>
<thead>
<tr>
<th></th>
<th>All households</th>
<th>Urban</th>
<th>Semi urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of households</td>
<td>2,595,000</td>
<td>1,820,823</td>
<td>375,728</td>
<td>398,449</td>
</tr>
<tr>
<td>Household’s disposable income</td>
<td>42,103</td>
<td>42,005</td>
<td>42,961</td>
<td>41,740</td>
</tr>
<tr>
<td>Household’s total consumption</td>
<td>35,770</td>
<td>35,988</td>
<td>35,416</td>
<td>35,107</td>
</tr>
<tr>
<td>Household’s total consumption on transport</td>
<td>6,110</td>
<td>6,041</td>
<td>5,978</td>
<td>6,542</td>
</tr>
<tr>
<td>Transport’s share of consumption</td>
<td>17.1%</td>
<td>16.8%</td>
<td>16.9%</td>
<td>18.6%</td>
</tr>
</tbody>
</table>

Consumption on cars and other motorised vehicles

<table>
<thead>
<tr>
<th></th>
<th>All households</th>
<th>Urban</th>
<th>Semi urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchasing of cars</td>
<td>2,219</td>
<td>2,211</td>
<td>2,103</td>
<td>2,366</td>
</tr>
<tr>
<td>Fuels and lubricants</td>
<td>1,420</td>
<td>1,253</td>
<td>1,717</td>
<td>1,901</td>
</tr>
<tr>
<td>Maintenance and repair</td>
<td>834</td>
<td>800</td>
<td>957</td>
<td>874</td>
</tr>
<tr>
<td>Spare parts and accessories</td>
<td>268</td>
<td>240</td>
<td>252</td>
<td>410</td>
</tr>
<tr>
<td>Other services</td>
<td>209</td>
<td>209</td>
<td>204</td>
<td>216</td>
</tr>
<tr>
<td>Vehicle provided as an employee benefit</td>
<td>182</td>
<td>229</td>
<td>99</td>
<td>49</td>
</tr>
<tr>
<td>Purchase of motorcycles, snowmobiles etc.</td>
<td>170</td>
<td>143</td>
<td>203</td>
<td>260</td>
</tr>
<tr>
<td>Total</td>
<td>5,302</td>
<td>5,085</td>
<td>5,535</td>
<td>6,076</td>
</tr>
</tbody>
</table>

Car’s share of consumption on transport | 86.8% | 84.2% | 92.6% | 92.9%

Considering the potential and challenges of MaaS in relation to households, also the income levels are interesting. More money is spent on transport the higher the income is, and as the income level grows, also transport’s share of consumption grows, meaning that these households use more of their money on transport. The difference is as high as 10.9% vs. 19.4% in the 1. (i.e. the lowest) and 5. (i.e. the highest) income bracket and in euros almost 10,000 euros, see table 8. It is worth to note that also the sizes of households differ and in the 1. income bracket there is on average one person whereas there are on average two persons in the 5. income bracket. The share of consumption on cars is the lowest in the 1. income bracket which reflects to some extent that many senior citizens and students are in this income bracket. From MaaS point of view, the households with the highest consumption on transport could be seen as the most viable market as these usually have a solid financial standing. Additionally, as non-car owning households are often in the lowest income groups, this presents also an interesting market. The challenge is to be able to generate enough revenue with the low-income households to be able to offer a comprehensive service meeting the customer needs.
Table 8. Households’ consumption in different income brackets on transport and cars in euros in Finland in 2012. (Statistics Finland 2017b)

<table>
<thead>
<tr>
<th></th>
<th>1. income bracket</th>
<th>2. income bracket</th>
<th>3. income bracket</th>
<th>4. income bracket</th>
<th>5. income bracket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household's disposable income</td>
<td>15,955</td>
<td>27,509</td>
<td>39,320</td>
<td>49,322</td>
<td>78,503</td>
</tr>
<tr>
<td>Household's total consumption</td>
<td>17,299</td>
<td>26,544</td>
<td>34,760</td>
<td>42,005</td>
<td>58,302</td>
</tr>
<tr>
<td>Consumption on transport</td>
<td>1,884</td>
<td>3,745</td>
<td>5,843</td>
<td>7,763</td>
<td>11,322</td>
</tr>
<tr>
<td>Transport's share of consumption</td>
<td>10.9%</td>
<td>14.1%</td>
<td>16.8%</td>
<td>18.5%</td>
<td>19.4%</td>
</tr>
<tr>
<td>Consumption on cars and other motorised vehicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchasing of cars</td>
<td>410</td>
<td>1,264</td>
<td>2,212</td>
<td>2,754</td>
<td>4,462</td>
</tr>
<tr>
<td>Fuels and lubricants</td>
<td>483</td>
<td>956</td>
<td>1,459</td>
<td>1,862</td>
<td>2,342</td>
</tr>
<tr>
<td>Maintenance and repair</td>
<td>362</td>
<td>621</td>
<td>687</td>
<td>1,137</td>
<td>1,364</td>
</tr>
<tr>
<td>Spare parts and accessories</td>
<td>45</td>
<td>97</td>
<td>223</td>
<td>370</td>
<td>606</td>
</tr>
<tr>
<td>Other services</td>
<td>105</td>
<td>190</td>
<td>232</td>
<td>248</td>
<td>270</td>
</tr>
<tr>
<td>Vehicle provided as an employee benefit</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>228</td>
<td>677</td>
</tr>
<tr>
<td>Purchase of motorcycles, snowmobiles etc.</td>
<td>15</td>
<td>101</td>
<td>219</td>
<td>192</td>
<td>323</td>
</tr>
<tr>
<td>Total</td>
<td>1,420</td>
<td>3,229</td>
<td>5,032</td>
<td>6,791</td>
<td>10,044</td>
</tr>
<tr>
<td>Car’s share of consumption on transport</td>
<td>75.4%</td>
<td>86.2%</td>
<td>86.1%</td>
<td>87.5%</td>
<td>88.7%</td>
</tr>
</tbody>
</table>

As can be seen from the figures of table 8, the amount of consumption on car purchase and fuels grows very steadily and rapidly as the incomes are higher. Replacing car ownership with the use of mobility services in a household could release several thousands of euros a year into these markets. The great challenge for MaaS from this perspective is to be able to offer a service meeting the customer preferences with acceptable costs, reflecting the households solvency. A key issue in this is to be able to show the true costs of car use which are often hard to be aware of and perceive. In the study by Tertoolen et al. (1998) it was seen that giving individually relevant information on the costs of car use leads to a higher estimate of own car costs.

5. Discussion

In this paper, the potential and challenges of MaaS in Finland were analysed from different perspectives based on statistics regarding the Finnish population and survey data on household consumption as well as mobility. These depict only certain kinds of potential and challenges, missing e.g. different lifestyles and the potential related to these. As e.g. lifestyles such as LOHAS (lifestyle of health and sustainability) and LOVOS (lifestyle of voluntary simplicity) could be linked to a strong interest towards MaaS as LOHAS stresses sustainability, which is something MaaS can support, and in terms of simplicity, MaaS offers potential to reduced car ownership. Yet, the challenge of transition towards more sustainable mobility is great. In the study by Aro (2016), the everyday practises in mobility such as car-driving, are clearly more tempting and include less inconvenience compared to sustainable mobility, and therefore allocating more time for travelling is not prioritised in the hectic life. Yet, MaaS trials have proved that substantial changes are possible. In the case of UbiGo, changes in travel behaviour were reported by 64 % of the participants, including decreases in private car use and increases particularly in the use of car sharing and bus and tram (Karlsson et al. 2016).

In this paper, biggest potential of MaaS in terms of geographical areas is identified in inner urban areas, where 32% of Finnish population dwell. The potential is linked to high population density, widest selection of different mobility services which can be bundled to MaaS, limited possibilities for parking and low car
ownership. From geographical point of view, the challenge is in the heartland and sparsely populated rural areas, which entail majority of land area and 17% of the Finnish population. For MaaS, the low population density and decreasing population mean low economies of scale and limited options of transport services to be bundled. Shared mobility services could be the answer for the challenge.

Regarding the different age groups, adults is the largest group in terms of population (2.0 million in urban areas, 2.8 in total) and most obvious customer segment from MaaS point of view. Also the children should be kept in mind when tailoring MaaS schemes, so that a household’s MaaS package could also serve the children’s mobility needs. As the 15 - 24 years old use more public transport than other groups, get less driving licences especially in Helsinki when turning 18 and may prefer access over ownership, this a especially interesting group for MaaS operators. As one potential and challenging group, the seniors, whose amount, especially those over 75 years old, will increase. For this customer segment, easy to use and access services are be preferred.

From households point of view, it is worth the note the big potential as annually 19.0 billion euros, the average of 509 euros/Finn/month, is consumed on mobility. This consumption is dominantly related to car ownership and use. The households with the highest consumption on transport are more than average car-based which is a challenge for MaaS. The bigger the family sizes are, the more cars there are in use. It is therefore a challenge to make the MaaS scheme so tempting that at least one of the cars would be replaced by mobility services. Potential is especially in one-person households. Almost half of these do not have a car in use, but the challenge is that these household are often low income households (students, seniors). Could a MaaS scheme be economically viable to serve these groups?

6. Conclusions

MaaS has potential to change the mobility practises of people. The potential is anyhow different in different geographical areas and for different population and mobility groups. It is important to recognise these differences to be able to assess the true potential and challenges of MaaS. MaaS offerings need to be tailored according to the different operational environments as the potential and challenges in different areas and potential customer segments vary.

By utilising different statistics and data on demographics, consumption and mobility in Finland, the analysis presented in this paper is mostly quantitative. Also the qualitative aspects are important and present potential and challenges to greater extent. The issues depicted by statistics in this paper, e.g. car ownership, could reveal more of the MaaS potential and challenges when analysed more qualitatively for example related to the environment and amount of car use. Regarding the MaaS potential, the study did not examine the changes that MaaS could have on mobility. This could be a further topic to study as well as having a wider outlook on MaaS. There is a need to combine different angles, and to comprehensively analyse critical questions, e.g. what problems and challenges can MaaS solve and address, where and to whom are these relevant, and what are the user perspectives on MaaS as a solution.
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The European Roadmap 2025 for MaaS

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JANA SOCHOR & MARIANNE KARLSSON Chalmers University of Technology, Sweden

Abstract

The purpose of this paper is to present European MaaS roadmap 2025, by describing drivers, enablers, market and MaaS services related to MaaS development in Europe. The main focus of this paper is on drivers and enablers, which are at the core of MaaS development and are pushing development towards the great vision of MaaS: offer user-oriented multimodal transport services on a one-stop-shop principle utilizing digitalization and mobile applications. However, there are still several open issues such as regulations, markets, business actors, and stakeholder collaboration affecting the future development of MaaS.

This paper is written based on MaaSIE – Mobility As A Service For Linking Europe – project, which was done during 1st of June 2015 to 31st May 2017. The MaaSIE project deliverable 2 works as a main reference for this paper and from there more detailed analysis and descriptions about the roadmap can be found. (Eckhardt et al., 2017) The project was organised in international collaboration between Finland, Sweden and Austrian research institutes. The primary research methods in this study were workshop method and literature review. During the MaaSIE project, together four workshops, one international workshop and three national workshops one in each participant countries, were organized to conduct the European roadmap 2025. Workshop 1 focused on future needs and visions for MaaS. Workshop 2 assessed and evaluated potential impacts of MaaS. In workshop 3, national roadmaps were defined and finally in the international workshop 4, all the previous results from national workshops were consolidated and future steps were identified.

As the outcome of the study, European MaaS Roadmap 2025, which is meant for all stakeholder groups who are related to MaaS development was developed. The roadmap is defined analysing short (1-3 years) and medium-term (4-9 years) actions and transition needed to reach the identified vision. The roles and responsibilities of all key stakeholder groups: academy and R&D, business, infrastructure & built environment, policy & regulation, technology & data, and social & culture, are studied in this timeline. Among stakeholder groups, the roles and responsibilities related to MaaS drivers and enablers vary and it can be stated that policy and regulation sector has the most important role, as it should work both, as the main enabler, but also as a key driver for the development.

The roadmap points out that in addition to the critical role of policy & regulation, stakeholders such as academy and R&D sector has an important role in MaaS development, since those should work as an enabler for identifying best practices, conducting an impact assessment, and developing living lab test environments. Also the business sector is seen as one of the key enablers, because the business sector is responsible for creating new pilots and services, collaboration and new business models and developing a one-stop-shop principle for mobility sector.

KEYWORDS Mobility as a Service, roadmap, workshop, European roadmap, drivers, enablers
Introduction

From a global perspective, and especially in the developed world, people’s standards of living has improved and housing and workplaces are concentrating on urban areas. However, at the same time, urban areas are expanding and people require more and more sophisticated leisure activities. These international trends are causing increased demand for travel and transport, because it is not possible to organize all kind of activities in each neighborhood. On the other hand, some trends such as digitalization, remote working and downshifting have been recognized to support the opposite development and hence to decrease mobility demand. However, the impacts from these opposing forces have not yet managed to undo the major developing trends in mobility sector. (Pöllänen et al., 2015)

Cities in particular, where infrastructure is relatively old and densely built, are already facing significant capacity challenges regarding infrastructure and financial resources. Resource challenges together with negative environmental impacts from transport, which are mainly caused by usage fossil fuels, are causing air quality problems necessitate improved planning and innovative mobility solutions. As transport infrastructure measures are mostly based on the traditional benefit-cost ratio analysis and while payback times are typically relatively long and usually these investments must be covered by the public sector, new and innovative approaches for transport sector is needed. It is also remarkable to notice that consumer habits and people attitudes towards owning and consuming are also changing, which provides opportunities for new mobility services. In this context, Mobility as a Service (MaaS), as an emerging key concept, aims at establishing combined and/or integrated mobility services.

The modern vision in mobility sector is built upon travel and mobility chains, where different transport modes are seamlessly integrated together. This vision provides end-consumers an opportunity to reduce dependence on their own car and hence develops transport system in a way, where private vehicles are losing their current dominance. In this development, mobility services are playing a vital role and thus mobility as a service model has been a buzzword in transport sector last few years. (see e.g. MaaS Alliace, 2017; Polis, 2017)

In this paper, the MaaSiFiE project’s definition for MaaS is used to describe what is meant with word MaaS in this context. A precise definition is seen to be very important, since MaaS is a very holistic approach to the transport sector and it can contain almost all aspects of transport and mobility sector. Below is the MaaSiFiE project definition for MaaS, which can also be considered as a research perspective of this paper.

“Multimodal and sustainable mobility services addressing customers’ transport needs by integrating planning and payment on a one-stop-shop principle” (MAASiFiE 2016)

As described above in the definition of the MaaS, consumer-oriented sustainable and easy to use mobility solutions are required from new mobility services. To achieve these requirements all different decision-making and actor levels must be able to do collaboration and push development in the same direction towards shared MaaS vision. In this paper, development path from status quo to vision 2025, i.e. European MaaS roadmap 2025 is presented. The roadmap is divided into four time windows: status quo, first 1-3 years, midterm future (4-9 years) and vision 2025. Each of these time windows is analysed via four MaaS development categories: drivers, markets, services and enablers. In this paper, the primary focus is on drivers and enablers.

In MaaS development different actors have various roles and while public sector should work as an enabler for the general development, service providers should be able to develop new attractive end-user services.
However, without modern technical and operational solutions new services cannot compete with a current private car-centric transport system. Thus, transport service providers and IT sector must be integrated closely into the development. Viable MaaS business models have not yet found and many different kinds of solutions can be recognised (see e.g. Eckhardt & Aapaoja, 2016).

Below "European MaaS roadmap” is presented including the roles of different stakeholders for a MaaS development in upcoming years. In methodology chapter the research methodology behind this roadmap is presented and finally this study is summarised in the conclusion chapter.

Methodology

The MaaSiFiE project was started with a state of the art analysis (SOTA-analysis), which included comprehensive literature review (see König et al., 2016). This state of the art and literature review was complemented during the whole project. The SOTA-analysis and literature review formed a solid premise for the project and these results have also been used in this paper.

The actual MaaS roadmap presented in this paper is based on the ‘LIFE’ method (see Figure 1), which derives from the methods called The Change Laboratory, Developmental Impact Evaluation and Road Mapping (Figure 1) (Halonen et al., 2010). The method is based on the series of workshops, which in this study were four. The first three workshops were held nationally in Finland, Sweden and Austria and the last was an international workshop. In each country, the Workshop 1 focused on future needs and visions for MaaS. The second workshop assessed and evaluated potential impacts of Maas from the point of views of MaaS stakeholders. The workshop 3 created national versions of MaaS Roadmap 2025, which were constituted with the TAO method: Transition, Actors, and Obstacles addressing which changes are required to achieve the vision, which are the actors and their roles, and what are the challenges. (Eckhardt et al., 2017)

The final international workshop gathered together national roadmaps and consolidated a European roadmap 2025. Part of the workshop 4 goals was also to define next steps for international MaaS development to ensure the continuity of MaaS implementation and promote the implementation of Maas on a European level. Below is described in more detail the content of each workshop. (Eckhardt et al., 2017)

![Figure 1 – LIFE method. (Modified from Eckhardt et al., 2017)](image-url)
Workshop 1, MaaS vision, was held in Finland and Sweden in December 2015 and in Austria January 2016. In Finland there were 40 participants and in Sweden and Austria about 10 participants. Participants represented public authorities, interest organizations, industry and research organizations. In each country workshop was started with an introduction of the project, the content and objective of the workshop. After the introduction, Finnish MaaS White Paper was presented and participants were asked to consider their reflections of the introduction about significant issues which for example, were or were not included, where they agreed and disagreed. After the individual work, the participants were divided into smaller groups (except in Austria, where participants worked in one group) to form a vision for MaaS. In the end, the results of small groups were presented and consolidated, factors prioritized, and significant issues, which should be added in the roadmap were identified. The most important factors from each national workshop are listed below. (Eckhardt et al., 2017)

In Finnish workshop, following factors were identified as most important:

- Branding: MaaS conceptualization and branding is seen essential to increase interest in MaaS. Value-added services themselves create and increase demand, and MaaS is considered to be mainly market-oriented, although it may also consist of subsidized transport.
- Quality assurance: For users, it is vital to ensure homogenous services or at least minimum service level and criteria regardless of the service provider. Professionalism in service production is also needed and emphasized.
- The MaaS ecosystem is a complex stakeholder network and hence a functional service system requires clear roles and responsibilities. Regulations and political decisions need to support and enable mobility services. Open, common and defined technology and programming interfaces have to be specified, including international roaming as well. Test labs for MaaS services would have a positive impact on the implementation of functional MaaS services.
- User-orientation: MaaS services have to take user needs and ease of use (e.g. a one-stop-shop principle) as well as door-to-door travel chains into account. A holistic, life approach should be considered and integrated when defining service needs as MaaS, like mobility in general, serves as an enabler of e.g., working, hobbies and land use. MaaS services have to serve different user groups with varying mobility and transportation needs. Moreover, it was seen essential to take into consideration changes in urban structures and the enabling impact of MaaS to keep the entire country habitable from the mobility point of view.

In Sweden participants prioritized following factors:

- Leadership is needed, but which stakeholder(s) would best act in this capacity is unclear.
- Policies and goals need to be established, including short- and long-term goals of what is to be achieved to be mapped against potential impacts (positive and negative) of different types of MaaS, so as to guide the decision-making and implementation processes better. Rules and regulations need to be modified, and a clear division of roles and responsibilities for various stakeholders will also facilitate moving forward. Other instruments such as urban planning and dynamic pricing need to be incorporated into achieving the larger vision.
- MaaS should be approached as an ecosystem with a user-oriented focus. Different types of MaaS will be needed to target different local contexts and requirements. The traditional divisions of public versus private transport should be modified to focus more on collective and shared transport. MaaS should focus on need-based mobility for instance on daily, seasonal, and phase-of-life bases.
Sustainability must be a prioritized goal of MaaS, including both environmental and social sustainability, e.g. equity and accessibility. Although there are many expectations of MaaS in these respects, it remains unclear as to what degree MaaS will be able to contribute to related national and local political goals.

Innovation is needed on multiple levels. Although physical barriers to MaaS need to be addressed, it is perhaps even more crucial to change mindsets and address mental barriers on both the individual and collective/organizational levels. The stage needs to be set for creative thinking and idea generation, and also to create the preconditions for other stakeholders to contribute to the MaaS ecosystem.

In Austrian workshop participants pointed out these factors:

- MaaS can be further developed upon the already existing modular, mobility service architectures, including multimodal traveller information, ticketing and sharing information components.
- Standardized service interfaces and data formats implementing MaaS to a large scale, needs to be made available on a national and international level to link different services and provide commonly available mobility platforms fulfilling the one-stop-shop principle.
- Since mobility needs to remain affordable to the society, a user-oriented approach understanding and fulfilling at its best the user needs and providing flexible services especially to vulnerable user groups as well, needs to be considered,
- Defining a clear MaaS framework having indicated roles and responsibilities required for the roll-out of the MaaS concept, together with applying new planning criteria and approaches (increasing the access to mobility) will path the way to a large scale MaaS deployment.
- Triggered by automation and digitalisation new meanings of different transport modes need to be considered for MaaS in future (Public transport will become more individualised, while individual transport will become more public). With this respect flexibility regarding combining and integrating different transport services needs to be considered and made available in terms of MaaS deployment.
- Increasing usage of “electronic wallets” together with increasing mobile connectivity fostering the provision and accessibility of MaaS in future. Further wireless network developments and deployments (e.g., 5G) provide users with higher data rates and thus allow high-quality service experiences in future.

According to the results, the three national workshops offered different types of input for the European MaaS roadmap. In Finland results focused on the policy and business perspective, the Swedish workshop took more of a general policy perspective, and in Austria, results concentrated on technology and data. The current know-how and level of MaaS adaption of course influences on these results. In Finland for example, Finnish Ministry of transport and communications has promoted MaaS development actively during the last few years (see e.g. Finnish Ministry of Transport and Communications, 2017), while in Sweden Ubigo pilot (see UbiGo, 2017) has got much attention. Moreover, in Austria national data platform has been in focus. The results from national workshops point out the importance of different perspectives at international level and diverse stakeholders, especially when focusing on a fundamental issue such as mobility and transport sector.

Workshop 2, impact assessment, focused on assessing and evaluating potential impacts of MaaS development. The workshop 2 also included socio-economic assessment based on MaaS experiences. As was done in the first workshop, also in the second workshop different viewpoints of MaaS stakeholders were noticed. The workshops were started with introductions followed by a presentation of the project. Also a summary of results from the workshop was presented. The main task in the workshop was to assess the MaaS service (see below for the service focused upon in each national workshop). Again, as in the first workshop participants first analysed the topic by themselves and then in small groups representing the same type of stakeholder (traveller/user, business, society). The participants analysed the impacts of their
MaaS experience: the practical consequences and meaning of the pilot/service on themselves and/or their organizations. Finally, all small groups discussed each theme (traveller/user, business, societal) in terms of impacts recognised before earlier.

The participants also had the chance to react to and discuss the expected impacts of MaaS as provided by experts via a questionnaire done earlier in the project (see König et al., 2016). At the end of the workshop, participants discussed desired development, i.e. how to achieve positive and avoid negative impacts, under what conditions, and by whom.

In Finland the workshop was held in September 2016 and the Ylläs Around pilot (see Ylläs, 2017) was the main pilot that was discussed. In general, all the stakeholders saw the pilot positive, and discussions among the actors developing the service had been good. The mobile payment was regarded very positive by users and transport operators, due to time savings and no need for cash. From public actor, a municipality, point of view the digitalization of transport data was found useful. However, the main challenge regarding the pilot was the delay in launching the service. The pilot was opened close to the end of the skiing season resulting and thus only a low number of users was reached. New ideas for Ylläs Around were mainly related to more detailed and precise information on the service and locations, pricing of the service and more extensive service packages.

In Sweden the workshop was held in February 2016 and in Sweden the focus was on the UbiGo. The stakeholders, who represented the individual/traveller, business, and societal perspectives, each reflected on how the pilot had influenced them. The workshop offered for UbiGo pilot users a chance to exchange their experiences, which they felt was important, as it helped to understand one’s understanding of others’ perspectives.

In general, users felt that the pilot provided added value to their lives, including reduced costs and facilitating making more sustainable choices. Organizations (public and private) pointed out that how the pilot had perhaps created some internal stresses, but it had also encouraged internal dialogues and strategies. Other desired future aspects and trends for MaaS were: increasing accessibility, but not necessarily demand/use; how to promote more environmentally sustainable choices (and vehicles) including sharing, active modes and not traveling; integration of digital and physical infrastructures; how to provide quality services for as many people as possible; and the division of roles and responsibilities.

In Austria the workshop was held in December 2016 and the participants represented the national road operator, the PT operator of Vienna, the Austrian ministry of transport, the national multimodal traveller information service VAO, and the platform for flexible mobility supply participated. The discussions focused on modular service framework, identified in the first workshop, identified mobility service items, expectations and estimations about potential impacts on the further development of MaaS services. Impacts, where evidence was available, were identified from the VAO service (VAO, 2017) and other pilot test cases like the road pilot and the SMILE project (Smile mobility, 2014).

Based on the detailed workshop procedure, identified impacts were classified into stakeholder groups: user/traveller, business and environmental/societal. Furthermore, these three categories were divided into identified respectively assumed effects. With the developing, global, private mobility providers like Uber or Car2Go new market players coexisting with national/local mobility providers are additional elements to be noted when thinking of potential impacts of MaaS on business. For end-users, harmonized ticketing/payment systems are enabling seamless service experiences. N.b. different domains for selling common tickets are
Currently available, but it is not clear to which extent future ticketing systems will be able to combine pricing schemes.

**Workshop 3, national roadmap 2015**, focused on defining short-term (1-3 years) and medium-term (4-9 years) actions and changes needed to reach the visions created in the first workshop. In Finland the workshops were in September 2016, in Sweden in December 2016 and the Austrian workshops were held in January 2017. The work was performed through four functional perspectives:

- Drivers
- Markets
- MaaS services
- Enablers

Actions and transitions were analysed in small groups and then participants used post-it notes to show results in the roadmap. Then presumably responsible actors were identified for these topics, presented for the whole group and finally participants prioritised them. The results of the national roadmap workshops were then integrated into a European roadmap, which was further developed in workshop 4.

In the Finnish MaaS roadmap 2025 workshop, the primary drivers of MaaS in the next one to nine years were related to the decrease in public funding and the environmental requirements. The primary enablers affecting MaaS in the short term consist of the development of the sharing economy, the solving of privacy issues, such as My data, and urbanization. Robotisation and automation were identified as the main enablers for MaaS development for medium-term perspective, but also changes in urban structures promoting public transport and sharing economy, as well as virtual services offering alternatives to physical mobility were highlighted. International collaboration and MaaS best practices knowledge were also identified as the key enablers in both the short and medium terms. In the short term, the main enabler is collaboration: between MaaS stakeholders creating new services, between transport modes and between municipalities and the national government. Other identified enablers included a quality commitment in building trust, and the development of innovative procurement practices and know-how in applying them.

In Sweden the key drivers for MaaS development were:

- Economy/convenience as it will become more expensive and more difficult to use a car, particularly in urban areas.
- Sharing becoming more accepted.
- Competition for regional budget resources.
- Incentives for sustainable transport, and for organizations to support such.
- Procurement procedures modified to support mobility instead of transportation.
- Sustainability goals for different actors as well as tied directly to MaaS.
- Changes in mindsets, e.g. opening up public transport.
- Power structures, e.g. shifting positions of money and power in the value chain.
- Ticketing/payment systems are becoming more standardized.
- Urban planning including densification, changing parking norms, etc
- Vehicle fleet shifts towards connected, automated, and shared vehicles.
- Scalability/customer perspective, i.e. a more fundamental understanding of customer needs and offering competitive, quality services that can be scaled up to larger solutions.
Moreover, the key enablers were:

- New business models e.g. many smaller solutions that can become of a larger, systematic solution; b2x and not just b2c; and learning how to value a customer that is a shared customer.
- Open up/building blocks such as opening and sharing data, and opening public transport tickets for resale (including APIs, different types of ticketing and pricing).
- Infrastructure, e.g. hubs.
- Contributions from agencies, i.e. understanding how agencies can contribute in additional ways than only economic.
- Laws/regulations: adapt/adjust regulatory frameworks and provide clarity from the public sector regarding goals/visions as this can increase interest from investors.
- Division of roles: a clearer division so that key actors can emerge to drive value networks and find business models.
- Knowledge exchange in the form of common MaaS platforms, e.g. conferences.
- Evaluations/new knowledge and new research: more action research is needed to understand what works and what does not, to understand the underlying factors to build upon, as well as objective evaluations of the societal effects of MaaS.

In Austria, the following issues were pointed as drivers and trends of MaaS deployment:

- Higher quality requirements (increased usage of common standards) improve the service experience and thus can increase the total number of users,
- Increased use of mobile technologies (very high smartphone usage),
- ”Using instead of owning” included in sharing mobility
- Increased (sub-)urbanisation
- Relocation of workspace to suburban regions
- Increased individualisation of user needs
- Incentive systems fostering the provision of new mobility services

In addition to this list, the deployment of 5G technology, more regular use of sharing economy services e.g. transport/vehicle sharing and an even higher degree of individualisation and increased cross-linking of services were also included in the 2025 Austrian planning period.

In Austria, MaaS enablers were analysed via potential roles and responsibilities required for deploying the national roadmap. The focus was on new roles dealing with digitalisation and automation and related tasks in order to organise sufficient MaaS value chains. Hence, also a qualified education (e.g. regarding data analysts) is considered as an enabling factor to achieve and operate new MaaS ecosystems.

Workshop 4, consolidation of results, the last workshops was held in Finland in Espoo February 3, 2017. Altogether 13 participants from seven European countries participated in it. During the workshop, results from national workshops were analysed and consolidated together to form European Roadmap 2025. The work was done by prioritising issues in the proposed roadmap, which done based on national roadmaps by the research group. Participants also had an opportunity to add new issues on the roadmap. The roles and responsibilities related to MaaS development were analysed by using me-we-us method (i.e. individually - small groups - whole group). Finally, technical recommendations and MaaS implementation plans was discussed by using me-we-us method again. In next chapter European MaaS roadmap 2025 in presented.
MaaS European roadmap 2025

To get an overview about general European MaaS Roadmap, below in Figure 2 is a simplified illustration about the roadmap. The roadmap consists of four-time windows: status quo, 1-3 years, 4-9 years and MaaS vision 2025 and each of these time periods is analysed via MaaS drivers, markets, services and enablers. Below in Figures 3-6 these MaaS categories has been divided further into six sub-categories: Academia and R&D, Business, Infrastructure & built environment, Policy & regulation, Technology & data and Society & culture to give more in-depth overview.

![European MaaS Roadmap 2025](image)

**Figure 2 – Simplified European MaaS roadmap 2025.** (Eckhardt et al., 2017)

According to the four workshops, policy & regulation is seen as the most significant driver for MaaS development (see Figure 3). Regulation should enable and push development forward by blurring the existing silos between MaaS stakeholders and transport modes. Regulation and reregulation should also work as a backbone for business model development, since with the current legislation, which in Finland does not well enough recognise sharing economy for example, some MaaS services cannot be legally implemented. With a transparent and harmonized regulation companies is easier to develop new business plans, which are also scalable. However, reregulation cannot be too open-minded, so that it does not drive unwanted ineffective development; i.e. policy and regulation should be used to encourage and guide the development of the transport sector towards more efficient and sustainable mobility solutions.

Although, policy and regulation are pointed out as the most significant driver of MaaS development, the desired development also needs significant input from business sector and end-users. The business sector, as a driver for the development, should work together and be able to collaborate more and to integrate more sustainable solutions into current and emerging business cases. From an end-user point of view, the sharing economy and end-users’ demand for personalised services are seen as primary drivers of MaaS development especially in terms of societal and cultural aspects.
The MaaS market sector needs PPP-collaboration (public-private-partnerships) and support from policy and regulation. According to the workshop results, the MaaS market is expected to grow and new market players will emerge during the next ten years (see Figure 4). During mid-term development, MaaS is supposed to find its role and position in the transport and mobility sector and it will become a significant part of the whole mobility market.

As a part of the development, MaaS business will be integrated together with current mobility market actors, such as the automotive industry. Also the role of transport data will increase which is supported by cross-sectoral ICT and digitalisation development, where ICT platforms, open data and standardised interfaces will expand. At the same time end-user awareness and acceptance towards MaaS will increase, which encourages companies to offer more personalised services for different user profiles.

<table>
<thead>
<tr>
<th>Why?</th>
<th>Status quo (2016-2021)</th>
<th>+ 1-3 years</th>
<th>+ 4-6 years</th>
<th>MaaS vision 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market</td>
<td>Academy and R&amp;D</td>
<td>Academy and R&amp;D</td>
<td>Academy and R&amp;D</td>
<td>Academy and R&amp;D</td>
</tr>
<tr>
<td>Business</td>
<td>MaaS corresponds only a minor part of mobility markets, what is the market potential?</td>
<td>- New market players, e.g. services that are alternative to cars</td>
<td>- MaaS markets are more stable</td>
<td>- Strong MaaS brand and demand for MaaS services</td>
</tr>
<tr>
<td>- New market players, e.g. services that are alternative to cars</td>
<td>- Services for such hours: e.g. bus, parking</td>
<td>- Business for integrated data and service market place</td>
<td>- Mobility services as a norm</td>
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<tr>
<td>- Services for such hours: e.g. bus, parking</td>
<td>- MaaS impacts on transport sector</td>
<td>- Automotive industry affects markets</td>
<td>- Profitable MaaS market</td>
<td></td>
</tr>
<tr>
<td>- Mobility services as a norm</td>
<td>- Developed ICT/IT architecture</td>
<td>- Impact on PF, e.g. brand, role and market</td>
<td>- What will happen to PT and subsidised transport (more commercial?)</td>
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</tbody>
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| Infrastructure & built environment | Infrastructure & built environment | Infrastructure & built environment | Infrastructure & built environment |
| Policy & regulation | MaaS hype (redefining transport mobility, services) | - MaaS hype (redefining transport mobility, services) | - Mobility services as a norm |
| - Fear of losing control (transport providers) | - Fear of losing control (transport providers) | - Impact on PF, e.g. brand, role and market | - Impact on PF, e.g. brand, role and market |
| - MaaS hype (redefining transport mobility, services) | - Fear of losing control (transport providers) | - Infrastructure & built environment | - Impact on PF, e.g. brand, role and market |
| - Fear of losing control (transport providers) | - MaaS hype (redefining transport mobility, services) | - Infrastructure & built environment | - Impact on PF, e.g. brand, role and market |
| - Mobility services as a norm | - Fear of losing control (transport providers) | - Infrastructure & built environment | - Impact on PF, e.g. brand, role and market |
| - Infrastructure & built environment | - MaaS hype (redefining transport mobility, services) | - Infrastructure & built environment | - Impact on PF, e.g. brand, role and market |
| - Infrastructure & built environment | - Fear of losing control (transport providers) | - Infrastructure & built environment | - Impact on PF, e.g. brand, role and market |

| Social and culture | Social and culture | Social and culture | Social and culture |
| Services come also to people | Services come also to people | Services come also to people | Services come also to people |
| Generation management, user demands etc. | Generation management, user demands etc. | Generation management, user demands etc. | Generation management, user demands etc. |

| Technology & data | Technology & data | Technology & data | Technology & data |
| Social and culture | Social and culture | Social and culture | Social and culture |
| Technology & data | Social and culture | Technology & data | Social and culture |

| Academy and R&D | Academy and R&D | Academy and R&D | Academy and R&D |
| Infrastructure & built environment | Infrastructure & built environment | Infrastructure & built environment | Infrastructure & built environment |
| Policy & regulation | Policy & regulation | Policy & regulation | Policy & regulation |
| - Preconditions in place for innovation and new fronts of collaboration | - Preconditions in place for innovation and new fronts of collaboration | - Preconditions in place for innovation and new fronts of collaboration | - Preconditions in place for innovation and new fronts of collaboration |
| - MaaS impacts on transport sector | - MaaS impacts on transport sector | - MaaS impacts on transport sector | - MaaS impacts on transport sector |
| - Fear of losing control (transport providers) | - Fear of losing control (transport providers) | - Fear of losing control (transport providers) | - Fear of losing control (transport providers) |
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| Technology & data | Technology & data | Technology & data | Technology & data |
| Social and culture | Social and culture | Social and culture | Social and culture |
| Technology & data | Social and culture | Technology & data | Social and culture |

| Academy and R&D | Academy and R&D | Academy and R&D | Academy and R&D |
| Infrastructure & built environment | Infrastructure & built environment | Infrastructure & built environment | Infrastructure & built environment |
| Policy & regulation | Policy & regulation | Policy & regulation | Policy & regulation |
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| Technology & data | Technology & data | Technology & data | Technology & data |
| Social and culture | Social and culture | Social and culture | Social and culture |
| Technology & data | Social and culture | Technology & data | Social and culture |

| Academy and R&D | Academy and R&D | Academy and R&D | Academy and R&D |
| Infrastructure & built environment | Infrastructure & built environment | Infrastructure & built environment | Infrastructure & built environment |
| Policy & regulation | Policy & regulation | Policy & regulation | Policy & regulation |
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| - Fear of losing control (transport providers) | - Fear of losing control (transport providers) | - Fear of losing control (transport providers) | - Fear of losing control (transport providers) |
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| - Fear of losing control (transport providers) | - Fear of losing control (transport providers) | - Fear of losing control (transport providers) | - Fear of losing control (transport providers) |

| Technology & data | Technology & data | Technology & data | Technology & data |
| Social and culture | Social and culture | Social and culture | Social and culture |
| Technology & data | Social and culture | Technology & data | Social and culture |

| Academy and R&D | Academy and R&D | Academy and R&D | Academy and R&D |
| Infrastructure & built environment | Infrastructure & built environment | Infrastructure & built environment | Infrastructure & built environment |
| Policy & regulation | Policy & regulation | Policy & regulation | Policy & regulation |
| - MaaS impacts on transport sector | - MaaS impacts on transport sector | - MaaS impacts on transport sector | - MaaS impacts on transport sector |
| - Fear of losing control (transport providers) | - Fear of losing control (transport providers) | - Fear of losing control (transport providers) | - Fear of losing control (transport providers) |
| - MaaS impacts on transport sector | - MaaS impacts on transport sector | - MaaS impacts on transport sector | - MaaS impacts on transport sector |
| - Fear of losing control (transport providers) | - Fear of losing control (transport providers) | - Fear of losing control (transport providers) | - Fear of losing control (transport providers) |

| Technology & data | Technology & data | Technology & data | Technology & data |
| Social and culture | Social and culture | Social and culture | Social and culture |
| Technology & data | Social and culture | Technology & data | Social and culture |

| Academy and R&D | Academy and R&D | Academy and R&D | Academy and R&D |
| Infrastructure & built environment | Infrastructure & built environment | Infrastructure & built environment | Infrastructure & built environment |
| Policy & regulation | Policy & regulation | Policy & regulation | Policy & regulation |
| - MaaS impacts on transport sector | - MaaS impacts on transport sector | - MaaS impacts on transport sector | - MaaS impacts on transport sector |
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| Technology & data | Technology & data | Technology & data | Technology & data |
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| Technology & data | Social and culture | Technology & data | Social and culture |

| Academy and R&D | Academy and R&D | Academy and R&D | Academy and R&D |
| Infrastructure & built environment | Infrastructure & built environment | Infrastructure & built environment | Infrastructure & built environment |
| Policy & regulation | Policy & regulation | Policy & regulation | Policy & regulation |
| - MaaS impacts on transport sector | - MaaS impacts on transport sector | - MaaS impacts on transport sector | - MaaS impacts on transport sector |
| - Fear of losing control (transport providers) | - Fear of losing control (transport providers) | - Fear of losing control (transport providers) | - Fear of losing control (transport providers) |
| - MaaS impacts on transport sector | - MaaS impacts on transport sector | - MaaS impacts on transport sector | - MaaS impacts on transport sector |
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| Technology & data | Technology & data | Technology & data | Technology & data |
| Social and culture | Social and culture | Social and culture | Social and culture |
| Technology & data | Social and culture | Technology & data | Social and culture |

Figure 3 – European MaaS roadmap 2025: Drivers. (Eckhardt et al., 2017)

Figure 4 – European MaaS roadmap 2025: MaaS markets. (Eckhardt et al., 2017)
In the European MaaS roadmap, ‘MaaS service’ development (see Figure 5) is seen to be driven by the business sector. First services will be tested and developed via pilots and then further extended to new services and business models. During the MaaSFiE project, various MaaS pilots were identified and development shows that pilots are now the leading development method to adapt MaaS services. However, according the results of the MaaSFiE project after three years, one-stop-shop services will be widely available and there will be some competition between services. At first, MaaS services will be adapted for passenger transport, but in the 2025 vision, freight transport will also be included into MaaS services.

As mentioned earlier under MaaS drivers, the policy and regulation sector has a significant role in enabling MaaS service development. Policy and regulation should be proactive and should spread knowledge about best practices and remove bottlenecks when necessary. For future MaaS services technology and data issues are key competitive advantages. Challenges related to personal data and quality of (open) data must be solved in general level to enable MaaS business actors chance to offer flexible and retailed services for end-users.

For end-users, “prosuming-model” (e.g. providing private cars to car and ride sharing networks), where consumer acts as a consumer and simultaneously produces services, will be interesting for MaaS service development. However, this kind of “prosuming” requires a significant change in consumer habits. On the other hand, from MaaS service providers, i.e. the business sector, this requires plug&play approach, where solutions are easy to use and at the same time attract consumers. When considering this kind of consumer habits changes in time scale, this development is seen as quite modest at the first and later on the development will proceed and produces useful services for a wider range.

<table>
<thead>
<tr>
<th>MaaS services</th>
<th>Status quo (2010-2017)</th>
<th>+ 1-5 years</th>
<th>+ 4-9 years</th>
<th>MaaS vision 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academy and R&amp;D Business</td>
<td>- Few pilots/service tests in Europe, even fewer properly evaluated</td>
<td>- Policy of pilots, of which the best ones will scale up and sharing lessons learned/test practices</td>
<td>- One-stop-shop travel services mainly in cities and for commuters</td>
<td>- One-stop-shop services available everywhere (bus, van, taxi, ...</td>
</tr>
<tr>
<td>Infrastructure &amp; built environment</td>
<td>- Low level of service integration</td>
<td>- Implementations (at least to some extent)</td>
<td>- Service combinations available, e.g. including freight and additional services</td>
<td>- Complement between services</td>
</tr>
<tr>
<td>Policy &amp; regulation</td>
<td>- Platform thinking, e.g. ecosystem for TV management</td>
<td>- Some more commercial services</td>
<td>- Additional services, tailoring and service networks</td>
<td>- Combining public and private sector transport</td>
</tr>
<tr>
<td>Technology &amp; data</td>
<td>- Infrastructure between transport modes (e.g. car sharing)</td>
<td>- Policy &amp; regulation</td>
<td>- Start of open data regulation</td>
<td>- Combining public and private sector</td>
</tr>
<tr>
<td>Social and culture</td>
<td>- Need to open up data/interfaces/ APIs</td>
<td>- Remove regulatory bottlenecks (which identified and resolved)</td>
<td>- Infrastructure &amp; built environment</td>
<td>- Combining public and private sector transport</td>
</tr>
<tr>
<td>- Lack of digital information</td>
<td>- My data management: secure information sharing between organisations under development</td>
<td>- Infrastructure &amp; built environment</td>
<td>- Technology &amp; data</td>
<td>- Combining public and private sector transport</td>
</tr>
<tr>
<td>- No common platforms</td>
<td>- Private cars as a part of public transport (public-private companies entity)</td>
<td>- Technology &amp; data</td>
<td>- Social and culture</td>
<td>- Social and culture</td>
</tr>
<tr>
<td></td>
<td>- Useful, flexible services emerge, helps to solve the &quot;we evolve&quot;</td>
<td>- Technology &amp; data</td>
<td>- More useful services emerge integrated with other aspects of life</td>
<td>- More useful services emerge integrated with other aspects of life</td>
</tr>
<tr>
<td></td>
<td>- Mobility &quot;prosuming&quot; (producing &amp; consuming)</td>
<td>- Technology &amp; data</td>
<td>- More sophisticated customer segments based on values and attitudes of people</td>
<td>- More sophisticated customer segments based on values and attitudes of people</td>
</tr>
<tr>
<td></td>
<td>- Easy access to information</td>
<td>- Technology &amp; data</td>
<td>- Technology &amp; data</td>
<td>- Technology &amp; data</td>
</tr>
</tbody>
</table>

Figure 5 – European MaaS roadmap 2025: MaaS services. (Eckhardt et al., 2017)
These experiences should also be implemented to procurement methods to enhance and improve general procurement processes; which is expected to happen during the next four to nine years.

For the MaaS business, the collaboration is seen as the most critical enabler and it should be adopted as soon as possible to national and cross-sectoral level. In mid-term development, collaboration should also be established at the international scale. In addition to collaboration, critical enabler for MaaS development which can be linked to business sector is matching of required service level and pricing, which is marked in the roadmap for the short-term period.

<table>
<thead>
<tr>
<th>Status quo (2016-2017)</th>
<th>1-3 years</th>
<th>4-9 years</th>
<th>MaaS vision 2025</th>
</tr>
</thead>
</table>
| **Enablers** | Academy and R&D  
- Actions to promote MaaS in academic research and education  
- Research and development funding available from several organizations (innovation agencies, transport authorities, CEDEF, EU...)  
- Business Infrastructure & built environment  
- National and international networks; e.g. national ITS organizations, MaaS alliance  
- Financial and strategies are under development Technology & data Social and culture | Academy and R&D  
- Ad hoc: MaaS research initiatives  
- Benchmark best practices / evaluation and societal impacts Business  
- Principle for cost/profit/subsidising  
- Cross sector operation models  
- Quality services offered to attract customers incl. minimum service guarantee  
- Increase availability of start-ups to investors  
- Development of one-stop-shop principle Infrastructure & built environment Policy & regulation  
- Clear regulatory framework, adjustments to regulations e.g. permission to resell PT tickets  
- Standardization of on/off common ticketing/payment system for public transport, data, service interfaces, APIs etc.  
- Change towards goal achievement (functional specifications)  
- Collaboration between service providers, actors, administration levels (e.g. municipalities and state)  
- Increased coordination between different public functions concerning subsidised transport and trips  
- Developing new procurement & PPP models and procedures, and know-how about their application  
- Emerging international MaaS collaboration (service and knowledge networks, conferences)  
- Develop national/regional political incentives to support MaaS  
- Marketing to public and policies to incentivise using MaaS  
- New ways of funding investments in e.g. metro  
- MaaS goals twill to policy goals and national goals Technology & data Social and culture | Academy and R&D  
- Systematic MaaS research  
- Continued work on benchmarking best practices  
- Development of living lab test environments (incl. policies) Business  
- Established international MaaS collaboration  
- All transport modes involved (companies + private persons)  
- New transport services  
- Combining different societal services Infrastructure & built environment Policy & regulation  
- Road capacity integrated with demand management  
- Green mobility and green transport established procurement knowhow, models and regulation  
- Facilitating flexibility and automation in place Technology & data Social and culture | Academy and R&D  
- MaaS integrated into education and the academic domain  
- Impact assessment framework in place Business  
- Viable business models (b2b, b2c, b2c2, b2o, b2p, ...)  
- Active collaboration in all levels, especially in business models e.g. sharing risks, rewards, customers) Infrastructure & built environment Policy & regulation  
- Guidelines e.g. for city planning and infrastructure design  
- Clear short- and long-term goals for funded services tied to societal goals  
- Clear roles and responsibilities of stakeholders  
- Holistic long-term coordinated planning and decision-making  
- Moderated political and economic instruments and steering to promote sustainable societal development Technology & data Social and culture |

**Figure 6** – European MaaS roadmap 2025: MaaS enablers. (Eckhardt et al., 2017)

In MaaS development, also academia and R&D activities are seen as an important enabler, since these sectors should provide a scientific approach for MaaS development, which consists of impact assessments, future studies and academic teaching for example.

As shown in the roadmap, research institutes should provide extensive international benchmarking and objective impact analyses about MaaS during the first three years. These actions should be aimed to improve knowledge and understanding about MaaS and its impacts on the whole transport sector, users, businesses, and society.

In the mid-term development MaaS studies should establish their status in the academic world and the research should be systematic. At the same time, research institutes should implement and stabilise living lab test environments and living lab approach to transport sector together with and for the business sector.

To summarise European MaaS roadmap 2025 contents, it can be stated that MaaS development is still in its early stage. There are still many open issues regarded to MaaS development and many of these are related to regulation. Moreover, while policy and regulation sector should enable and push MaaS development business sector should be able to develop new attractive mobility solutions, which can compete with private cars. Finally, end-users must find future MaaS services and be able to change their mobility patterns.
Conclusions

According to the definition of MaaS, its services should offer user-oriented services and promote political goals, such as sustainability and accessibility. Regarding this holistic approach and ambitious vision it is not surprising that the expectations for MaaS are high. At the national level, the current stage of MaaS development is in the pilot phase, where various MaaS pilots have been implemented, but the viable large-scale commercial services are still missing. When considering international level countries mostly have their own approach to MaaS development. However, when MaaS concept is getting more and more attention also the attitudes and expectations on it are becoming uniform and shared vision is taking its shape.

At the moment, various MaaS pilots and some services already exist, but it is still uncertain how MaaS business models and stakeholder responsibilities will develop and if they will be sustainable in the long term. Regulation is one of the major enabler and driver for the MaaS development, which also gives a regulatory framework for the business sector to develop and implement new MaaS services. However, different countries have their own regulatory approach on MaaS and in many countries regulation is going to be scrutinized in next few years. Hence, it can be stated that the future of MaaS is complex and same unexpected factors might significantly impact on future mobility services.

In addition to regulation, drivers such as service culture, technological developments, environmental targets and public sector efficiency requirements will support collaboration between different sectors and MaaS services. These factors will promote MaaS development, but finally the success in mobility market depends on the innovation capability of the business sector and end-users acceptance.

In the MaaS development, the technological development also has a significant role, since multimodal mobility services require technical interoperability between stakeholder platforms and IT-systems. The public sector can drive this interoperability by adopting interoperability issues to public procurements. At the same time, academia and R&D sector should also be able to provide new innovative solutions to integrate different transport modes together, in a way that data and information flow can be secured.

In this paper, European MaaS Roadmap 2025 is presented including main activities, general findings and vision of MaaS development. All the results presented in this study has been gathered in MaaS FiE project from literature and transport sector actors and stakeholders who participated in the workshops. Altogether several international transport and mobility experts have been involved in the project via interviews and workshops. However, while MaaS development is still in its early phase, lack of real data was affecting on roadmap analysis. Without data it was difficult to make sophisticated impact analysis. Thus one of the main outcomes of the MaaS FiE project was to point out that similar roadmap work should be done again after few years.
References


User perspectives
Searching for the potential of MaaS in commuting – comparison of survey and focus group methods and results

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Abstract

There is abundant statistical data available on commuting behavior and its determinants. However, the existing data on the prospects and the potential of MaaS in commuting is highly limited. To fill the gap we have collected new kinds of commuting data using focus group method and a mobility survey on commuting behavior in Finland. The purpose of this paper is to discuss the kinds of information and conclusions that can be obtained from these two complementary data collection methods.

The study is part of the project Smart Commuting – Smart and Mobile Work in Growth Regions that explores new ways of combining work and life on the move with intelligent and sustainable transport system services. The project aims first, to identify the changing needs of mobile workers. Second, the project aims to increase sustainability of mobility by supporting and implementing new mobility concepts. This helps scale up our business partners’ operations, evaluate how these new concepts meet the evolving needs of mobile workers, and discover common grounds for the city planning policies1.

KEYWORDS MaaS, mobility, service, commuting, survey, focus group

1. Background

Mobility-as-a-Service is a new way of thinking and implementing transportation services. MaaS Alliance defines MaaS as the integration of various forms of transport services into a single mobility service accessible on demand (https://maas-alliance.eu). Typically, a MaaS includes at least 1) integrated multimodal journey planning, 2) selection of alternative mobility modes and 3) route choices and booking or ticketing (König et al. 2016). Also, different package and subscription discounts and help desk services are often available. In future, transportation of goods and other additional services may become part of MaaS.

In a MaaS network, there is an operator that is responsible for the integration and the provision of flexible services with the customers, and the service providers that offer their transportation services that are integrated in the operator’s system. Some of these services are part of the public transportation while others may be offered by private firms. Fast evolving digitalization and new transport services (e.g. Uber) have further increased the possibility to combine different modes of transport into MaaS. These new alternatives are aimed to solve the last-mile problem. (Haahtela et al., 2017)

1 This project is a part of the ERA-NET Cofund Smart Cities and Communities (ENSCC), which was established by the Joint Programming Initiative (JPI) Urban Europe and the Smart Cities Member States Initiative (SC MSI). This two-year project started in April 2016 and will last until May 2018.
To enhance MaaS’ development, we collected data on the factors that affect the individuals’ choice of the daily commuting mode. Our second goal was to recognize the kinds of changes and future services would be needed by individual commuters to change their present mode of mobility. A special interest is related to the topic of shifting from private car(s) to more sustainable and environmental friendly commuting modes.

The research methods used in our study are a survey and focus groups. The survey data on the daily commuting modes is derived from more than 500 answers in the three countries involved in the Smart Commuting project: Finland, Switzerland and Austria. The focus group were organized earlier and their results were used to get new insights and ideas for the survey. In particular, the purpose was to design the initial survey questions on the basis of the focus group results. If the initial survey question or set of question did not seem to be able to reveal some phenomenon, the survey questions were modified or added in a way that they would reveal these incidents. We also investigated the difference between the results of the focus groups and those of the survey: what kinds of topics could the focus groups reveal that a survey cannot, and vice versa: for what kind of questions is a survey more appropriate data gathering method in comparison with the focus groups. Our goal is to further develop the empirical methods for studying commuting and mobility.

The paper is structured as follows. In Chapter 2, we describe the methodology and the main findings of the country surveys. In a similar vein, the method and the findings of the focus groups are discussed in Chapter 3. Chapter 4 cross-evaluates the main features of the two methods and their ability to generate complementary information related to individuals’ commuting behavior. The paper ends with conclusion and discussion in Chapter 5.

2. Survey

Method

By definition, survey methodology studies the sampling of individual units from a population and the associated survey data collection techniques, such as questionnaire construction and methods for improving the number and accuracy of responses to surveys. Survey methodology includes instruments or procedures that ask one or more questions that may, or may not, be answered (Beam, 2012). Our survey aims to highlight the structure and the diversity of the present commuting modes as well the changing needs of mobile workers in three countries: Austria, Finland and Switzerland (Basel). The questions of the questionnaire are focused on the following themes (no. of questions): respondents’ background (18), commuting environment (5), present modes of commuting (13), satisfaction and motivations (5), and the future modes of commuting (3). The survey questions and the report are available in www.smartcommuting.eu/publications deliverable D1.2 Survey results of the mobile workers’ needs.

The geographic focus of the survey differs in each country, which in part reflects the policy priorities and needs in developing sustainable commuting. Accordingly, the resulting data is based on three identical (region-adjusted) commuting surveys in Austria (N = 531), focusing the whole country, Finland (N = 523) focusing on the Finnish Growth Corridor and Switzerland (N = 549) focusing on Basel Region. Owing to the large sample size the data enables compare the descriptive statistics across the three regions/countries and - based on the statistical clustering methods - identify commuting profiles within each country/region and across the three countries/regions.
The Finnish data (forced n=521) is collected from the Growth Corridor Finland using the internet panel method of Taloustutkimus in December 2016. Based on representative sampling, half of the Finnish responses were collected from municipalities and small towns, whereas the other half are from the four large cities (Helsinki, Espoo, Vantaa, Tampere) located in the Growth Corridor Finland (see http://suomenkasvukaytava.fi/briefly-in-english/ for more details on GCF). Along with place of living, representative sampling was applied to other central background variables; age and gender. Owing to the sampling method and the characteristics of the panel almost all responses are correct and completed.

The main survey results

Many of the findings of our survey are consistent with the earlier findings of the national commuting surveys and statistics. The dominant mode of commuting is private car which is used by over 50% of the respondents (see Figure 1). The use of a private car is nearly a de facto in rural areas, while public transport is common in urban areas. Another statistically significant finding was that men use more private car than women in commuting, while women tend to use more public transport. Household income is positively correlated with the use of private car.

![Figure 1: Distribution of the commuting modes in Growth Corridor Finland](image)

While Finland is characteristically a country with low average population density and long distances, the survey showed that the average commuting distances and time are very similar in all three regions. The place of living defines strongly the mode of mobility. Regardless of where people live, most of the workplaces are in cities. While working is generally considered as a useful activity during commuting, it is surprising that only 6% of the survey respondents actually work during commuting. Using electronic devices for leisure is by far more common (27%), followed by reading (12%) and calling (11%).

The open question concerning the kinds of tools, infrastructure or services is needed in during trips gave a number ideas for improvement. Passengers require more quiet spaces for working and soundproof places where they can make company calls. In the buses, people would first need a place to sit. Also, some respondents wrote that their employees should provide them better tools for mobile work. For example, using a laptop while sitting in a bus is not possible while working with a tablet would be. Also, some vehicles lack good internet connections and power sockets. Some employees would require a permission to work during commuting. Also, according to some collective agreements, working during commuting is not regarded as working. Then, some respondents said that they would need some smart alarm system to ensure that they get out the bus or train on the right bus stop.
On aggregate, we found that commuters are satisfied with their present mode of mobility: more than 80% are satisfied or very satisfied. In general, the satisfaction is higher in Growth Corridor Finland than in Austria and Basel region (see Figure 2). Based on the ANOVA tests, there is no interdependencies between the levels of satisfaction and the modes of mobility. Dissatisfaction is not associated with specific modes of mobility either.

![Figure 2: Commuting satisfaction in different case areas.](image)

The most significant drivers to encourage commuters to use more public transport as 1) more frequent service, 2) decreased travel time, 3) cheaper tickets, 4) better connecting services, 5) tickets provided by employer and 6) improved reliability of public transport. It is very common to combine other activities to commuting. Shopping is by far the most common: nearly 80% of the respondents combine shopping with commuting often or sometimes. Also, social activities, leisure or sports or using public services are combined with commuting trips at least sometimes. Education (17%) and picking-up someone (15%) are less common activities.

We also asked motivations for using different modes of mobility. Car users prefer flexibility, speed, reliability, privacy and the opportunity to transport goods. Also, bad access to public transport and good availability of free parking motivate car users. Commuters using other modes – public transport, cycling and walking – have very similar motivators. They justify modal choices by environmental concerns, price, flexibility, health, speed and flexibility.

3. Focus groups

Method

Focus group is a form of qualitative research data collection method consisting of interviews and discussion in an interactive group setting in which a group of people are asked about their opinions, beliefs, and attitudes towards a selection of topics. A typical size for a focus group is six to ten people led though open discussion by moderators. The optimal size of enough participants is needed to generate rich discussion, but the number has to be limited so that none of the participants and their ideas are left out. When well executed, a focus group creates an accepting environment that puts participants at ease allowing them to thoughtfully answer questions in their own words and add meaning to their answers. Also, in comparison with the individual
interviews, the discussion between other participants enriches others’ thoughts. While surveys are good for collecting information about people’s attributes and attitudes, focus groups provide understanding at a deeper level (Fern, 2005).

We arranged six focus groups in autumn 2016 in the growth corridors of Finland: two in October in Hyvinkää in the Growth Corridor Finland (a region between the capital area and Tampere region) and four in Turku in November in the southern growth corridor (region along the southern coast from Turku to capital area and Hamina). All 37 participants of these focus group sessions were selected by invitation. In Hyvinkää, participants were selected so that they work in the Growth Corridor Finland and commute from a distance of at least 50 km either by car or by different modes of transport. The participants in Turku, invited by the city representatives, were more heterogenous in terms of the commuting distance. In all six focus groups, the participants had higher education level than the population on average. Participants also had more children and larger family sizes than average Finnish population or those answering the survey.

The description of the focus group sessions

Each focus group session was divided into two sections. In the first section, we gathered information about the present daily commuting habits of participants. In the second section, we investigated how the forthcoming Mobility-as-a-Service and other similar concepts could change their personal and family commuting and mobility behavior. Each focus group lasted between 30 to 60 minutes.

In the first section of the focus group, each participant was asked to illustrate and draw a simplified picture of his/her typical daily commuting. The reason for using a drawing was to make people feel more relaxed when describing their commuting. It was also easier to discuss and share the own contribution with others if the picture can be used as a framework for explanation. To encourage the participants, a simple illustration model picture was shown to the participants as an example. The picture was supposed to show 1) the modes of transportation, 2) the distance and 3) time taken by the commuting mode, and also to illustrate 4) what other activities (e.g. shopping, dropping kids to school, sports and social activities) were combined with commuting.

After that, participants presented their daily commuting patterns to others and told why they had chosen the alternative or alternatives they were using. This discussion was recorded so that both the drawn illustrations and their explanations could be combined for the analysis. These explanations also revealed the motivational aspects affecting individuals’ choice of commuting mode.

The second section started with a short video that explained the Mobility-as-a-Service concept to the participants. After that participants draw and wrote in their pictures the possible changes that MaaS could have in their commuting patterns. The participants were encouraged to discuss different alternatives. During the second section we also applied a threshold method (See figure 3). We asked what kind of services participants would like to have in future that could change their mobility patterns. To stimulate their thinking, we suggested several different new services and ideas, e.g. car sharing services, ride sharing, grocery home delivery and using electric bikes. The purpose was to find out what kinds of services would be the ‘threshold services’ that would make them change their commuting patterns. Of special interest was the kind(s) of solutions that would be needed to change from using private cars to for more sustainable alternatives.
Focus group findings

Commuters seem to choose either walking or bicycle for their daily commuting if the travelling distance is at most 3 - 4 kilometers. In Finland, usually after the distance of 2 kilometers, half of the trips are already made by car (Liikennevirasto 10/2015). If the commuting distance was longer than 3 - 4 km, commuters used public transportation or private car. Typically, private car users told they save significantly time, half an hour or more, when using their own car instead of public transportation.

Commuters’ children saved time when the parents either took them at school or picked them up by car. If the family had not used the car, their children would not have enough to time to come home, eat something, do the homework and go to their leisure activities: using private car simply saves so much time. Also in the outskirts of the city, the headway between the buses was considered too long.

It was noticed that there are significant annual fixed costs related to owning a car, but the variable costs of driving additional kilometers is low. Once the car is bought, it is used also for those trips that could be made by other modes. Using a private car is even in some cases less expensive than public transport. For example, if someone needs to buy two different monthly local public transport tickets and then also a monthly ticket for train, using own car is not only faster and more flexible but also less expensive.

There were also different work-related topics that supported use of the private car. A common reason for commuting with a car was that participants needed it in their work. Different external meetings and sites were not easily accessible without own car. Sometimes a private car is the only mode of commuting allowing work related phone discussions or joining in teleconferences.

Some participants said they like driving a car and would therefore anyway prefer it as a way of commuting. Driving a car and listening to their favorite music gave them some free time to relax. Some commuters also considered the health benefits of walking or using a bicycle as part of the transport chain. For them, also safety and aesthetics determined the chosen route.

Another finding was that commuters having children combined often other activities with their commuting. The two most common tasks were bringing kids to kindergarten or school and doing groceries. The third
most common activity was sports. Without these ‘side-tracks’ some of these people would have used public transport as their main mode of transport.

When discussing their daily commuting and choice of transport mode, it became clear that choosing the place of living and the choice of commuting are related to each other. Some families rather live outside the city area in a larger house and use cars for daily commuting and other activities. There are families who live in smaller apartments closer to the city center and use public transportation for daily commuting. Both commuter groups justified their choices by their values: some prefer more space and freedom while others want to live closer to the services and to support green values.

The satisfaction to the chosen mode of transport was on average good. For longer distances, train was considered a good alternative as the time spend on train was often used either for working or used as spare time. The most significant challenge for long distance commuters in the growth corridors was the last mile problem and matching the timetables of different commuting modes. The latter is partly due to the fact that train and bus stations are often not in the same location, nor even in the city center. Also, buses leave the passengers to the bus stops at highway instead of driving to the city center. Therefore, travelling between two cities in the corridors is difficult unless at least another end of the trip is close to the bus or railway station.

Another obstacle is that to speed up trips between larger cities, trains pass often the smaller cities. Some growth corridor commuters must take a car to get to the train station, and sometimes even drive to the opposite direction of their final destination. In these cases, it becomes easier to drive directly to the destination.

**Needs for future commuting and MaaS**

When thinking about future commuting possibilities and MaaS, participants mostly had very limited views of the future and how their mobility patterns would change. Most of the ideas were related to the improvement of some present modes of transport, for example, having smaller headways in public transport. Also, many of the ideas presented were already implemented by some public transport authorities.

The most common need was to have a mobile application that would integrate all the different modes of transport, show different vehicles in real time and allow buying ticket for the whole trip. Also, possibility for re-routing in case of delays was high in the list. Other typical suggestions were:

- Real-time information on the location of the public transportation vehicles (buses, trams, trains etc.). This information could be shown in the bus stops and when the following buses are expected to arrive.
- Enhanced travel chain optimizer application that would dynamically suggest alternative travel chain alternatives if the original one is not feasible anymore, e.g. due to delays. The same application could also announce when it’s time to leave the vehicle.
- A service that would tell different alternatives between the destination and current location. User could choose between different alternative travel chains based on price, travel time, CO₂ emissions etc. Also, the ability to buy the ticket for the whole travel chain from the mobile application would ease using public transportation.

Commuters hoped that buses would stay more on schedule and that the headways were shorter. Railway commuters suggested 1) silent cars for sleeping or working purposes, 2) better internet and electricity connections, 3) possibility to have a cup of coffee and a snack in trains and stations (at least a vending machine) and 4) having a gym or exercise bikes in the train. Commuters using bicycles were mostly satisfied
with the present situation. They recommended 1) better cycling opportunities and roads, 2) more and better bicycle parking lots next to the stations, 3) possibility to take bicycle into the train for a reasonable fee, and 4) use of different gritting sand in the winter to lower the risks of tire punctures.

A new national level ticket pricing system was also considered to be a necessary. The price should be based on the distance instead of the somewhat artificial zones used (or there should be more smaller zones so that the payment would be based on the price of the zones travelled). The present monthly ticket pricing should also be changed so that those travelling only three times a week would also get discounted prices. This would encourage commuters to use public transportation instead of a private car.

Brining kids to their hobbies was considered demanding and time-consuming tasks. Several parents suggested that a good new service would be to ease the transportation of kids to their hobbies. Some company could take that responsibility of that, or it could be an application or a service where people could interact and share the transportation related costs. Some parents also suggested that similar concept could be used for school transportations in the morning. The school buses common in the USA were also suggested. Another benefit would be safety, as some parents considered the way to school to be quite dangerous because of the traffic.

Commuters were not eager about ride sharing. Some argued they would feel uncomfortable in a car with a stranger. In that case, their schedule would be more dependent on others’ travelling times. Ride sharing would be a viable alternative only if there were many commuters people offering rides via some mobile services. On the other hand, different car sharing models (floating or fixed stations, peer-to-peer or company cars) were seen as viable options if the prices are competitive.

Finally, there is a distinct lack of MaaS-related services, especially for the last miles. To improve the present situation, the participants using buses for longer distances suggested a service, continuous shuttle bus to city center, or some other alternative. Even in the cities new mobility solutions are needed outside the rush hour, especially in the outskirts.

4. Analysis and results

In this study, we have employed two complementary data collection methods to examine the patterns and motivations in commuting. Survey can be used to show the overall structures and phenomena of commuting related issues that can be generalized to a larger population, whereas focus groups are more appropriate for examining the motivations, complexity, and the social interdependencies of commuting at the individual levels, and in real contexts.

Both methods show that commuters are highly satisfied with their present modes mobility. Regardless of the mode, commuters prefer the same dimensions of satisfaction: flexibility, speed, reliability and ease of use. What mostly seems to determine the mode of transport is the time difference between using a private car and other transport modes. This became quite evident especially in the focus groups. Furthermore, if there are children in the family, and therefore more mobility needs, it is more likely that the family uses a private car to save time.

According to our survey, 51% of the commuters still use car as a primary mode of transport. While owning and driving a car has lower status than earlier, our focus group revealed that car driving in commuting is motivated by enjoyment, particularly among middle-aged and older men. Furthermore, commuters would be willing to change to shared cars if the prices and service level were right for their needs. The propensity
to increase the use of public transportation is higher among the car drivers in comparison with the whole sample. Public transport a specific advantage of allowing other activities during trips: reading, working or enjoying digital entertainment during the trip. Contrary to our expectations, working during commuting is relatively uncommon.

None of the 37 participants in the focus groups had ever used car sharing or shared ride services in Finland. Only a few had ordered groceries to home. According to the survey results, commuters use less internet for seeking commuting information, booking and paying than in Austria and Switzerland. On the whole, Finnish culture is not very service-oriented. If customers bought more groceries online, as many already do in case of music, books, electronics and clothes, a private car would become unnecessary and time would be saved for other activities. Hence, if commuters had more experience on the different new mobility services, it would be easier to adopt and take full advantage of the ‘Maas concept’.

Overall, our separate findings show a significant potential for MaaS services. Commuters are willing to shift to public transportation, and some user groups in the families, particularly children, are unable to drive a car. MaaS with rich selection of services would provide them better opportunity for mobility. Therefore, it should be of significant public interest to enhance MaaS and simultaneously guide mobility towards more sustainable solutions.

Complementary data collection methods

In this study, qualitative and quantitative methods are combined to highlight the multiple facets of commuting. Focus group was used for exploratory purposes to understand what commuters think, and also how and why they think that way. Focus groups allow flexibility to make changes and dive deeper into more interesting topics and phenomena that arise during the conversations. The advantage of focus groups is that it provides in-depth knowledge of commuting in individual cases. This helps understand the user needs both on the individual and the household levels. Focus groups revealed several options for innovations and improvement.

Survey was used to make conclusions on the larger population of commuters. We reflected the background factors with the commuting environment, the present modes of commuting, satisfaction and motivations, and the future of commuting. For that purpose, we included multiple choices, rating scales and open-ended questions. In terms of budget, timing and the quality of data, internet panel survey proved highly effective. A distinct drawback of the survey method is inflexibility; once you have started running a survey, you cannot make changes or additions to improve it. For instance, we realized that the survey cannot go into the complexity of motivations, why families prefer private car to other modes of mobility.

Originally, our aim was to use focus groups as a tool for design of survey questions, which is also the standard handbook recommendation. The findings of the focus groups suggested that the relevant topics could tackled with highly detailed questions in the survey. This would have made the questionnaire too extensive and burdensome for the respondents, which necessitated some compromising with the research questions. Moreover, we concluded that it may be more practical to use both methods in parallel to investigate different but complementary issues of commuting.

According to our survey, only 15-25% of commuters could imagine of using the ‘new modes’ of commuting (car sharing, shared on-demand transport service, on-demand service or bike service). In contrast, when the same questions were asked in the focus groups, most of the participants were favorable towards them. This highlights the fundamental differences of the two methods.
When the questionnaire deals with unfamiliar and novel concepts, the respondents rather than stopping to think about the question further, tend to skip the questions or answer negatively. The context is different in the focus group sessions; participants have more time and they can be guided to think the topic from their own perspective. In our focus groups for instance, the participants first thought of and visualized their commuting patterns with a picture and text. This enabled imagine how the new concepts could be used in their own contexts. Moreover, if some service concepts were unclear, it was possible to have clarification and further information from the moderator.

The focus groups also benefit from social interaction and group dynamics. Typically, the groups seem to compose of different types of characters between ‘proactive innovators’ and ‘passive followers’. The former generates multiple ideas and possibilities on the smart traffic services. Through their example and enthusiasm, the innovators stimulate the latter to imagine and discuss how the new services and solutions could help their commuting and life.

We notice that after three to four focus groups, the generation of new information starts to saturate. Therefore, if statistical accuracy is not needed, which is often the case with focus groups, there is no need to organize additional focus groups with similar topics and participants. If there is an opportunity and resources for higher number of focus groups, it is more productive to focus on specific user groups and themes in commuting.

Another potential use of focus groups would be to test and brainstorm some specifically targeted MaaS-related service idea with a test group. Then, after a pilot launch and test use of the service, focus groups could be used to get feedback for further service development.

5. Conclusions and discussion

This paper investigates the kinds of information and conclusions that can be obtained from two complementary data collections methods in estimating the potential of Mobility-as-a-Service in commuting. For that purpose, we examined the commuting patterns and behavior through the empirical data collected by a survey and focus groups.

According to the survey and focus group results, the commuter cannot yet identify the usability and value added of the new emerging modes and services like MaaS. However, focus group method revealed latent needs of the participants that can be solved with MaaS and related concepts. Moreover, both methods showed that the most relevant unit of analysis is not an individual commuter but the family and household which determines the prerequisites for travelling of the family members.

For future improvement and development of MaaS systems and the related services, we need more detailed information on the mobility behavior of the family members: In practice, collecting such a comprehensive data requires a mobile application that registers the log automatically. Once this data is available, it is possible to assess suitability of different modes of commuting and mobility for the households. For instance, log data enables modelling and simulating how much different existing MaaS-related services could possibly save time and ease the life in the families. Then, it can be estimated what could be the value, benefit and costs of a new services both to the customer, service providers and the society.

We conclude that survey and focus group methods complement each other. Both methods reveal that there is a demand for MaaS and new innovative Maas-related services among the users. Furthermore, the methods show that the reasons why private cars are used in commuting, are highly rational. In particular, commuting
modes and the places of living are interdependent “value issues” decided jointly within families. This interdependency also explains the high levels of satisfaction with their present modes of commuting.

The survey does not provide sufficiently in-depth knowledge that would help understand user-specific mobility needs on individual and household levels. Focus group method is more appropriate in this sense. Such knowledge on user needs and motivations are of high importance for decision makers – e.g. municipal authorities, city planners, traffic planners, transport authorities and MaaS-related service providers - when planning the sustainable future mobility with MaaS and Maas-related services.

6. References

De Verkeersonderneming

De Verkeersonderneming (VO) is a public private cooperation of the municipality of Rotterdam, the metropolitan region Rotterdam-The Hague, the national Ministry of Infrastructure and Water Management and the Port of Rotterdam. In the national program Beter Benutten (Optimizing Use) industry, science and government work closely together to implement smart solutions: improving traffic flows, reducing congestion and making smooth travel safer, less time-consuming, cheaper and more comfortable. De Verkeersonderneming is the executive organisation for running this program in the region of Rotterdam.

An important role for MaaS in our Smart and Sustainable Mobility program

Due to the continuing popularity of urban environment and the economic strength of this region, the demand for mobility continues to rise. The current modal split, with a dominance of private car use, will have a negative impact on the accessibility and livability of the urban area in the short term. And even now, for example, the city center of Rotterdam does not have enough space for all citizens, employees and visitors, despite the increasing attention for spatial planning and infrastructure in the city. On the other side, there are problems of transport poverty. About 5 to 10 percent of the population, concentrated in some parts of the city, are more or less immobile, which means that not all people have full access to jobs, access to care, access to education and access to their social network, factors that contribute to social deprivation and loneliness.

Both issues require that a larger proportion of mobility will be filled in with other forms of mobility. These forms mainly involve modalities that require less space and less environmental impact, such as walking, cycling, clean vehicles and public transport. This will make an important contribution to friendlier living space in the inner cities, which can be used better by more people of all ages, and will make more opportunities for everyone who wants to participate in society.

In the opinion of De Verkeersonderneming, MaaS is a concept that offers a mobility solution that is seen by travelers as a full-fledged alternative of travel by car. With MaaS, travelers are able to fill in a larger part of their mobility needs by modalities that reduce the need of spatial impact and the infrastructure, because the proportion of walking, cycling, PT and car sharing will increase. The expectation of De Verkeersonderneming is that when a substantial proportion of people living and working in the urban area uses MaaS, this, accessibility and livability will improve, or at least not deteriorate. Because research shows that a positive business case for MaaS is possible (Decisio, 2017), MaaS can also offer mobility opportunities for people with less access to mobility. In this way, MaaS also increases opportunities for more people, which contributes to an inclusive city. Therefore, in the Smart and Sustainable Mobility program 2018-2021 of the VO, an important role is given to Mobility as a Service.
The prospective perspective of MaaS

The VO believes that the future situation with MaaS in the Rotterdam region will look like this:

- Residents of the urban area do not need their own car anymore to meet their mobility needs.
- Residents of the rural and low-urban area have more mobility options than their own car to meet their mobility needs, even in peak hours.
- A clear number of MaaS providers are actively offering mobility options.
- A large proportion of residents and employees use a MaaS provider to meet their mobility needs.
- Roaming enables MaaS customers to use services from other MaaS providers, allowing national and internationally travel from door to door via MaaS.
- There are MaaS bundles available for different groups with different mobility needs, including people who currently use special traffic services.
- The MaaS providers work together with traffic management authorities to make optimum use of the available mobility network.
- In urban area, space pressure has decreased sharply by a reduced number of parking spaces, made possible by a high-quality range of mobility services. MaaS helps people and businesses to settle in the urban region because of the good accessibility there is an attractive traffic and transport system and the public space has a high quality.
- A ‘social return of investment’-system increases mobility chances of those groups in the city that face exclusion.

On the way to the prospective perspective

To reach this future situation, De Verkeersonderneming has developed the Marketplace for Mobility. On the basis of described needs of customer groups, in a tender the market was asked to offer mobility services, whereby they receive a reward per (verified) realized structural excitement. This resulted in a wide variety of mobility services. In the last tender, services that allow door to door mobility where offered. This tender has resulted in a consortium of service providers operating in a large part of the region, providing a (developing) MaaS platform with planning, booking, traveling, supporting, adjusting and paying functionalities. Passenger cars, e-bikes, ferry, water, taxi and public transport are offered in the platform.

This Marketplace for Mobility has made possible an important step towards the prospective perspective described before, but this perspective is not realized yet. That is obvious, because the tenders did focus on finding solutions for traffic jams in rush hours, while the MaaS perspective is broader. On the way to the prospective perspective, it is necessary to set up both small and largescale experiments and projects, in which De Verkeersonderneming will learn what is needed precisely, what barriers should be eliminated and what preconditions should be created, moreover to not only generate effect on traffic fluidity, but also on spatial, climate and social efficiency

At the moment, it is not clear what MaaS exactly will look like. The above-described perspective will therefore be adjusted and sharpened in practice. De Verkeersonderneming has developed a plan of approach in which the first concrete projects are mentioned which will bring the prospective perspective closer. In this plan concrete short-term needs and issues are included (such as improving accessibility of the airport, or providing mobility services at urban densification sites). In addition, the VO examines which issues need to be solved to increase MaaS services in general, in cooperation with other urban regions and the national government (to enable MaaS trips throughout the Netherlands and internationally).
On the way to MaaS via three tracks

To reach the prospective perspective, on the short-term favorable conditions have to be created, so market parties can offer strong MaaS services. The plan of approach has therefore been set up as a three-track plan:

1. **Cooperation with the market.** Organizing collaboration with the market, in the form of procurement, contests, pilots, experiments, etc., aimed at scaling up MaaS and realizing and optimizing social (mobility) goals.

2. **Research projects.** To get a good MaaS service, first answers must be found on numerous questions, for example questions about data use, technology, effects on spatial-, climate-, social- and traffic-fluidity efficiencies, and especially traveler needs, an often underestimated aspect of Mobility as a Service.

3. **Connect MaaS initiatives.** In the Rotterdam region, several parties work on the development of Mobility as a Service. Consideration must be given to the extent to which scaling is desired, within the region, within the province and beyond, and to what extent stakeholders want and can collaborate in the development of MaaS. In addition, it is important to co-operate with regional, national and international MaaS initiatives.
SPECIAL SESSION

MaaS in rural areas
Demand Oriented Mobility Solutions for Rural Areas Using Autonomous Vehicles

Feasibility of the implementation of SAVs as sole mobility solution

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This study was funded by Opel Automobile GmbH and DB Regio AG

1. Introduction

Conventional public transport in rural areas is facing major difficulties, especially in countries exhibiting demographic and societal changes. In rural areas in Germany demographic change and the accompanying decrease in population and pupil numbers endanger the already bristle financial situation of public transport.

Accordingly, in most rural areas only major links to and from cities are serviced by public transport. The offered services mainly are an extension to school bus service, adding only few additional trips to the schedule to assure a minimum of mobility for the public. Most of the mobility demand in rural areas is covered using private vehicles. Considering demographic change, more seniors will become dependent on mobility through private vehicles, who might not want to or should not drive anymore.

This paper explores the opportunities presented through the dawn of autonomous vehicles and their application in a new mode of public transport. This study is conducted exemplarily on a rural administrative district (AD) in Northern Bavaria in Germany. Using a household mobility survey available from that district, the public transport demand is modelled as trip requests and serviced with a new transport mode utilising shared autonomous vehicles (SAV).

Conducting this study, major trends are taken into consideration to estimate public transport demand and supply for rural areas in Germany in the future.

This study delves into answering questions about feasibility, vehicle utilisation and accessibility through SAVs. A model of a typical rural area in Germany is established to show the implementation of SAV service.

The focus of the model is not to represent all traffic in the rural area but only to show the new public transport mode SAV. The main results will be information about the number of vehicles needed to achieve a certain level of service during peak hours, average passenger detour per trip, overall vehicle kilometres driven daily and average billable trip-km per passenger and vehicle.

This paper sets the focus on the first results applying 4-seated SAVs to cover a demand of about 30% in the underlying administrative district.

Research goal

This paper tries to establish the feasibility of changing mobility to completely rely on SAVs for motorised transport. The implemented simulation focuses on a population extrapolated to the year 2030, where autonomous, electric vehicles could potentially be on the market and gaining market shares.
2. **Background (policy and society)**

Flexible mobility solutions e.g. carpooling have been tried repeatedly in Germany. However, they have never caught on and most public trials featured major financial problems. Today most carpooling services supporting public transport are subsidized through local governments. They are merely an addition to regular taxi services mostly confined to one municipality. In some areas, partially flexible bus services are gaining momentum. This is especially evident in rural areas with high tourism potential.

However, today, conventional carpooling is picking up momentum through a rise in the sharing economy. Services like Uber and Lyft are in successful operation in urban areas in the United States and car sharing schemes are gaining attention in German cities as well [Shaheen, Mallery, and Kingsley 2012; Shaheen, Stocker, and Bhattacharyya 2016].

With the example of Lisbon, it has already been shown that shared taxi services could reduce the number of cars in large cities by up to 80% when getting rid of private vehicles altogether [KLOTH Michael 2015]. Similar studies have been conducted in Hamburg [kirschner 2016] and Stuttgart [Friedrich and Hartl 2017].

This study however will focus on sharing rides in rural areas, where there are different conditions compared to inner city mobility. Average trip distance is longer and there are potentially fewer people that could share a ride [Statistisches Bundesamt 2016].

In the dawn of autonomous driving, flexible mobility solutions surface again. New economically viable options for carpooling are appearing. On the supply side, getting rid of personnel in transit vehicles is hoped to be linked to reduced operation costs and reduced fares. In Germany personnel costs in public transport make up of about 1/3 of all operational costs (reduction from 55% of operational costs down to 22% are thinkable) [Loos 2016; Bundestag 2016].

2.1. **Definition and Characteristics of Rural Areas in Germany**

Defining rural areas in Germany, one can resort to the BBSR (Bundesinstitut für Bau, Stadt- und Raumforschung) which distinguishes between four different spatial settlement structures [BBSR 2014].

- **City:** A City has more than 100,000 inhabitants.
- **Urban districts:** Districts with a at least a 50% share of the population living in a density of at least 150 people/km² or districts with a density (without cities) of at least 150 people/km².
- **Rural districts with agglomeration tendencies:** Districts with a 50% share of the population in cities under 150 people/km² and districts with an average density of 100 people/km². 
- **Scarcely populated rural districts:** Districts with a population share in cities under 50% and average densities lower than 100 people/km².

Even though people are moving to cities [STATISTICHES BUNDESAMT 2016; SHELL 2014; CHILLA, MORHART, AND BRAUN 2008] still about 50% of the population lives in rural areas in Germany. This part of the population could face major difficulties with declining public transport services. On the other hand, an increase in service quality could improve living conditions and reduce the dependencies on private car ownership.
2.2. Autonomous Driving (as utilised in this study)

This study takes for granted the ubiquity of safely functioning autonomous vehicles in a few years. Additionally, this study opts for the implementation of fully electric vehicles. However, in this step battery capacity, charging time and location of chargers are not considered.

2.3. Trends (changes in rural districts)

Public transport in Germany is a public service and supposed to facilitate mobility for everybody. However, due to cost constraints, public transport in rural areas is often merely an absolute minimum service, building on school bus service to obtain a certain economic feasibility.

Implementing a public transport built on autonomous shared vehicles might be the major step to an affordable, flexible, good quality service that might even be cost effective.

Conventional public transport is in peril in rural areas. Several societal trends are affecting people’s lives and the public transport customer base as well. The following figure depicts societal mega trends and their effects on demand and supply of mobility. These trends feed into changes in transport operation form, transport operation model and vehicle concepts.

![Figure 1: Trends affecting rural districts in Germany](image-url)
3. Overall model structure

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum trip duration</td>
<td>Shortest time to get from Stop A to Stop B using a fastest route algorithm</td>
</tr>
<tr>
<td>Detour coefficient</td>
<td>Actual trip duration from Stop A to Stop B (with detour) / minimum trip duration from Stop A to Stop B</td>
</tr>
<tr>
<td>Trip request [hours]</td>
<td>Time amount the trip request is placed/handled before the requested departure time</td>
</tr>
<tr>
<td>Flexibility [minutes]</td>
<td>Tolerance a trip departure can vary from requested departure time. Once set, the dispatched departure time can only be adapted in a 10 minute range</td>
</tr>
<tr>
<td>Requested departure [hh:mm]</td>
<td>Time and Date of a departure request</td>
</tr>
<tr>
<td>Transit marker</td>
<td>Utilised as a random factor to represent different levels of modal split</td>
</tr>
<tr>
<td>Min trip [minutes]</td>
<td>Short trips that are not being depicted in the model. The assumption being that these short trips will be conducted on foot or by bike.</td>
</tr>
<tr>
<td>Billable distance [km]</td>
<td>Sum of all minimum trip distances (shortest/quickest Route from Stop A to Stop B)</td>
</tr>
<tr>
<td>Vehicle kilometres (veh-km)</td>
<td>Sum of all distances driven</td>
</tr>
<tr>
<td>Vehicle kilometres occupied</td>
<td>Distances driven with passengers</td>
</tr>
</tbody>
</table>

Figure 2: Definitions as used in this paper

The model is written in Anylogic 8. Anylogic 8 is a java based multi method simulation environment. The simulation created for this research is an agent based model, representing a realistic simplification of a public transport operation using SAVs. The following agents were created for building the model:

- Stops
- Passengers
- Dispatcher
- Vehicle (SAV)

Furthermore, the model accounts for the following specifications:

- Model duration 24+ hours (model runtime 20:00 day before till 03:00 day after)
- Simulation of only the new transport mode
- Not a complete traffic simulation (no delay, no traffic jams, no differences in travel times due to congestion)
- Travel times and driving speeds are obtained from OSM (see data used)
- Dispatcher tries to gain high vehicle occupancy rate
- Maximum detour coefficient per passenger (actual travel time / optimum travel time per passenger)
- Demand – all “public transport” trips except:
  - Trips with a duration < 5 minutes as these trips are most likely conducted on foot or by bike (duration < 1 minute for seniors)
  - School trips conducted via rail
  - School trips along major arteries towards the one major school site (demand for school trips would highly exceeds the overall demand peak, as all students must be at school at the same time)

Stops and Passengers are static agents that do not change during model runtime.

Stops are implemented to serve as origin and destination.

Passengers have origin, destination and a trip request time for which the dispatcher tries to find a suitable vehicle.

The Vehicles follow a list of Stops generated by the Dispatcher, checking at each Stop if Passengers nett to get on or off.
The Dispatcher is the main agent running the model. A trip request comes in (for this paper 2 hours before the requested departure) and the Dispatcher tries to find a suitable vehicle. Vehicles are excluded from the search if:

- the Vehicle has no capacity
- the Vehicle cannot get to the new origin in time
- detour for the new Passenger or Passengers already in the Vehicle exceeds the set limit
- requested departure time cannot be realised +/- Flexibility

If all criteria are met, the Passenger is allocated to the closest Vehicle (at dispatched departure time) with Passengers aboard, if this is not possible the closest Vehicle (at dispatched departure time) without Passengers is chosen. After a departure time is dispatched it can only be shifted in a 10-minute period to maximise carpooling possibilities.

4. Data used

Stops

Theoretically, door to door service is possible using autonomous vehicles. However, for this model, a less dense stop distribution is chosen. Under the assumption that almost everybody can bear a small offset between door and nearest stop, stops with a 100 m catchment area were placed covering most of the settlements in the district excluding single houses and farms. The model incorporates 1,588 stops (a detail of the map is shown in Figure 3). However, considering providing mobility for everybody, impaired citizens would need the option to be picked up or dropped off directly at the door.

![Map showing stops in red (100 m catchment area). map data OSM/Geofabrik.de July 2017](image)

Figure 3: Map showing stops in red (100 m catchment area). map data OSM/Geofabrik.de July 2017

Demand

Demand is extrapolated from a mobility household survey conducted in an administrative district (AD) in Bavaria, Germany from 2014. The household survey showed an overall return rate of around 14 %, which is unusually high for such a survey conducted in Germany. Students showed some overrepresentation due to the survey being promoted in schools. The extrapolation and normalisation was done utilising demographic information for the administrative district for 2012 (status quo) and 2030 (prognosis) [Bertelsmann Stiftung 2017].

The trips requested in the model do not represent the whole extrapolated mobility demand. Different modal splits for SAV usage can be implemented through a uniformly distributed variable “transit marker” (shown in Figure 4). “Trip requests” depicts the time difference between reservation of the trip and actual requested departure time. “Flexibility” depicts the time interval in which the trip can begin (here +/- 30 minutes from requested departure time). All Stops are assigned a unique ID to be addressed in the model.
Supply

On the supply side, the focus lies on smaller vehicles than average public transport vehicles to maximise flexibility. This model can incorporate vehicles with 4 and/or 8 seats. The vehicle fleet size can be set as varying parameter with the goal of servicing all trip requests. Using the Agent Dispatcher that is adjusted for high efficiency in vehicle use, an excess supply of vehicles can be detected and can be reduced for further research, if needed. However, the vehicle fleet size should not be chosen too large as the Agent Dispatcher runs through all vehicles for every trip request resulting in longer model run times. The dispatcher prioritises the vehicle choice firstly for vehicles that already have passengers and secondly for the vehicle detour.

Routing

Routing is done via the street network available through OSM-Maps [© OpenStreetMap Creative Commons BY-SA 2.0]. The maps are obtained through Geofabrik GmbH. Fastest routes in between all stops are then determined utilising speed limits for driving speed. These driving durations are used in an O-D-Matrix covering roughly 2.5 million trip combinations. This O-D-Matrix is utilised in the Agent Dispatcher for the determination of a good travel time for each trip request.

Fleet Size

Fleet size, usually a flexible parameter, is fixed at 1,800 vehicles for this comparison. Fleet size is chosen larger than needed to compensate for a lack in cleaning, maintenance, charging time. Even though, results will show that vehicles cover longer distances than possible for EVs on one charge.

Vehicle Size

Vehicle sizes are chosen in similarity to vehicles available today. Focusing on a rural area, with a disperse population a high mean occupancy in SAVs is very unlikely. 4- and 8-seated SAVs are therefore chosen as suitable vehicles.

<table>
<thead>
<tr>
<th>Passenger type</th>
<th>Origin ID</th>
<th>Age</th>
<th>Trip reason</th>
<th>Destination ID</th>
<th>Trip request [hours]</th>
<th>Flexibility [min]</th>
<th>Requested departure [hh:mm]</th>
<th>transit marker [1-100]</th>
<th>Min. trip [min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>working</td>
<td>450307</td>
<td>58</td>
<td>work</td>
<td>9901100</td>
<td>-2</td>
<td>30</td>
<td>06:45</td>
<td>62</td>
<td>5</td>
</tr>
<tr>
<td>student</td>
<td>350307</td>
<td>8</td>
<td>school</td>
<td>350110</td>
<td>-2</td>
<td>30</td>
<td>06:00</td>
<td>84</td>
<td>5</td>
</tr>
<tr>
<td>other</td>
<td>150801</td>
<td>29</td>
<td>supply</td>
<td>123201</td>
<td>-2</td>
<td>30</td>
<td>08:10</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>senior</td>
<td>450307</td>
<td>73</td>
<td>supply</td>
<td>9901100</td>
<td>-2</td>
<td>30</td>
<td>09:10</td>
<td>45</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 4: Example of trip demand data utilised in the model
5. Model results

5.1. Model parameters

For this paper, different scenarios with a fixed fleet size of 1,800 vehicles were examined. For the following parameters variations were modelled:

- Vehicle size: 4 and 8 seated vehicles
- Max. detour coefficient: 1.0, 1.2, 1.4
- Flexibility: 0 min, 10 min, 30 min

A detour coefficient of 1.0 and flexibility set at 0 minutes depicts regular taxi service, where shortest point to point connections are desired.

As this paper's goal is to cover the whole mobility demand with SAVs, 100% of demand is utilized in the model. However, as there will always be some part of demand that is conducted by motorised transport, a certain share is left to biking and walking. For this model, the non-motorised share is defined through a minimum travel duration (as shown in Figure 5). The dispatcher does not regard these trips and as such the realised demand for motorised transport is reduce to about 75%.

<table>
<thead>
<tr>
<th>User group</th>
<th>Working</th>
<th>Student</th>
<th>Apprentice</th>
<th>Senior</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modal split in SAVs base: all trips</td>
<td>100 %</td>
<td>100 %</td>
<td>100 %</td>
<td>100 %</td>
<td>100 %</td>
</tr>
</tbody>
</table>
| Minimum travel duration [minutes in a vehicle] and equivalent distance (min * 30 km/h) | 5  
(2,500m) | 5  
(2,500m) | 5  
(2,500m) | 1  
(= 500 m) | 5  
(2,500m) |

Figure 5: Utilised modal split for each user group

5.2. Detailed Model Results (1,800 vehicles)

In Figure 6 to Figure 9 results of a single model run are shown. This run was conducted with a maximum detour coefficient of 1.4, a flexibility of +/- 30 minutes, a fleet size of 1,800 SAVs. The fleet size was set to 1,800 to make sure that all trip requests can be served.

All trip requests are served (Figure 6), the mean detour coefficient settles at 1.22 and not all vehicles are utilised simultaneously. The gap between vehicle kilometres (veh-km) and vehicle kilometres occupied in Figure 7 depicts the distance travelled without passengers. The fleet covers 541,295 veh-km, with 73,345 veh-km travelled without passengers (13.55 %). The sum of all billable trip-km (all trip requests – shortest route without detours) totals at 1,051,761 km, which is 194.30 % of the distance travelled by all vehicles. In a kilometre based tariff, this would be the total billable distance to all passengers. Which means that almost twice the actual travelled distances could be monetised in a km-based tariff.
Figure 6: Trip Requests for 100% demand and trips not restricted to AD (1,800 8-seated SAVs; max. detour coefficient 1.4; flexibility +/- 30 minutes)

Figure 7: Covered distances for 100% demand and trips not restricted to AD (1,800 8-seated SAVs; max. detour coefficient 1.4; flexibility +/- 30 minutes)

Figure 8: Vehicles in Motion for 100% demand and trips not restricted to AD (1,800 8-seated SAVs; max. detour coefficient 1.4; flexibility +/- 30 minutes)
Figure 9: Vehicles’ occupancy for 100% demand and trips not restricted to AD (1,800 8-seated SAVs; max. detour coefficient 1.4; flexibility +/- 30 minutes)

Figure 10: Vehicles’ occupancy for 100% demand and trips not restricted to AD (1,800 4-seated SAVs; max. detour coefficient 1.4; flexibility +/- 30 minutes)

Figure 11: Km per vehicle per day + operation hours per vehicle per day for 100% demand and trips not restricted to AD (1,800 8-seated SAVs; max. detour coefficient 1.4; flexibility +/- 30 minutes)

Figure 8 shows the number of vehicles that are in motion during the simulation run. High vehicle occupancy occurs especially during peak hours, as can be expected. At maximum 1,158 vehicles are utilised simultaneously during the morning peak (Figure 9). Figure 11 shows that the mileage of about 1/3 of all vehicles exceeds that of today’s average EVs (up to 350 km on one charge). Single vehicles in the model even reach up to
950 km in a single day. This could be spread more evenly with increased fleet size or through implementing battery capacity and charging into the model. Operation hours leave enough time for cleaning, servicing and charging for the vehicle fleet. Comparing Figure 9 (8 seaters) with Figure 10 (4 seaters) differences in vehicle utilisation can be observed. With 8 seaters fewer vehicles are utilised featuring higher occupancy.

5.3. Results Parameter Variation

<table>
<thead>
<tr>
<th>Max. Detour coefficient</th>
<th>Average quality service</th>
<th>High quality service</th>
<th>Taxi Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>1.2</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flexibility [minutes]</th>
<th>Average quality service</th>
<th>High quality service</th>
<th>Taxi Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

**Figure 12:** Parameter variation on a fleet size of 1,800 4- or 8-seated vehicles

To determine flexibility and acceptable detour factor different sets of parameters are simulated. Figure 12 shows these parameter sets. An average service quality can probably be ensured with high detour factor and high flexibility in dispatched trip starting times. Whereas higher quality service needs a lower detour coefficient and taxi-like shuttle services no detour at all. Figure 14 shows detailed results for 8-seated vehicles. 4-seated vehicles were simulated as well, a simplified comparison of billable and empty veh-km is shown in Figure 13.

A lower detour factor increases (in this simulation setup) the share of trip requests that cannot be served. However, no detour increases this share considerably compared to the moderate change from 1.4x to 1.2x.

Additionally, reducing flexibility leads to an increase in trip requests not being served as well. Reducing flexibility implies fewer possibilities of adapting new trip requests to fit already dispatched trips.

Reducing flexibility from +/- 30 minutes down to +/- 10 minutes only changes results slightly. A reduction down to a flexibility of +/- 0 minutes shows a grave reduction in served trip requests and billable kilometres. This confirms the assumption that flexibility is needed to match trip requests to shared vehicles. Even in the taxi service scenario a reduction of flexibility down to +/- 0 minutes shows a larger impact than the reduction to +/-10 minutes.

Comparing simulations where all trip requests are served, the billable distance per vehicle averages at 584 km whereas the average mileage for vehicles is around 330-360 km. In total these results point out that in a kilometre base tariff using shared vehicles almost twice the travelled distances could be billed to customers.

Upper and lower boundaries of daily mileage per vehicle vary widely. Where some vehicles are only used briefly (11 km/day) others are utilised quite extensively (900 km/day) which could not be covered using a single charge, considering electric vehicles. However, some optimisation can surely distribute usage more evenly between all vehicles, enabling enough possibilities for breaks for charging, cleaning and maintenance.
On average, each vehicle (in a flexible sharing scenario) services 45 trip requests per day. The taxi service scenarios are showing a lower average with around 35-38 trips/day.

The demand could be serviced with a smaller vehicle fleet. There is still room for optimisation in adapting fleet size and dispatching algorithms. An optimisation has not been conducted for this study. Especially, when looking at the operating hours of vehicles (Figure 11), vehicles could be operating longer per day. However, for servicing the morning peak about twice the number of vehicles are needed compared to covering the average daily demand.

With these results, it is reasonable to assume that a mobility service built on shared autonomous vehicles is feasible in rural areas and could possibly be run economically feasible.

In Figure 13 the share of billable kilometres compared to the overall sum of vehicle kilometres is depicted. Comparing simulation results with 4 seaters and 8 seaters larger vehicles show a slight advantage in pooling rides. 8 seaters vehicles exhibit a share of up to 195% billable kilometres where 4 seaters vehicles exhibit only a share of up to 160%. The advantage in utilising larger vehicles mainly lies in covering demand peaks. However, in most cases, vehicles transport less than 4 passengers (Figure 9).

The morning peak has a large share of pupils going to school. For serving these trips with small vehicles it is important to consider the quantities of vehicles needed to transport pupils in a small time frame and secondly if drop off zones in front of schools could handle the number of vehicles. For handling higher demand that can be pooled for one destination, it is probably better sticking to scheduled line based service, possibly expanded through flexible feeder services guaranteeing the connection to the scheduled service.

The decision between 4 seaters and 8 seaters will probably be an economic one. If 8 seaters are only slightly more expensive than 4 seaters these might be preferred. On the other hand, a service focusing on comfort and hoping for higher revenue might rather consider 4 seaters.

![Figure 13: billable and empty veh-km for 4 and 8 seaters](image-url)
| Fleet Size | 1,800 |
| vehicle size | 8 seater |

| Study area | Administrative district + nearby cities |
| Max. detour coefficient | 1.4 | 1.2 | 1 |
| Flexibility [min] | 30 | 10 | 0 | 30 | 10 | 0 | 30 | 10 | 0 |
| Realised demand | 74.91% |

| Trip requests | 74,563 | 74,563 | 74,540 | 74,563 | 74,540 | 74,540 | 74,563 |
| Trip requests served | 74,563 | 74,531 | 64,885 | 74,513 | 64,885 | 64,885 | 64,885 |
| Trip requests not served | 0 | 32 | 0 | 0 | 0 | 0 | 0 |
| Trip requests not served | 0% | 0.04% | 0% | 0% | 0% | 0% | 0% |

| ∑ vehicle km [km] | 541,295 | 548,548 | 1,016,113 | 591,748 | 1,025,766 | 1,120,236 | 1,119,258 |
| ∑ veh km occupies [km] | 467,950 | 470,140 | 759,968 | 489,039 | 761,349 | 798,396 | 799,136 |
| ∑ billable [km] | 1,051,761 | 1,051,418 | 860,832 | 1,051,759 | 855,112 | 896,079 | 871,415 |
| ∑ veh km empty [-] | 73,345 | 78,408 | 256,145 | 100,767 | 264,417 | 321,840 | 320,122 |
| max. No of vehicles in operation simultaneously | 1,766 | 1,766 | 1,766 | 1,766 | 1,766 | 1,766 | 1,766 |

| Distances per vehicle | Min [km] | 11 | 16 | 227 | 37 | 44 | 158 | 316 | 14 | 160 |
| Distances per vehicle | Max [km] | 872 | 907 | 842 | 845 | 868 | 866 | 887 | 951 | 854 |
| Distances per vehicle | Average [km] | 333 | 336 | 571 | 367 | 361 | 577 | 630 | 627 | 64 |
| Distances per vehicle | Billable distance per vehicle [km] | 584 | 584 | 478 | 584 | 584 | 475 | 498 | 484 | 446 |

| Operation time per vehicle | Min [hh:mm] | 0:10 | 0:12 | 4:31 | 0:44 | 0:53 | 3:11 | 6:18 | 0:16 | 3:27 |
| Operation time per vehicle | Max [hh:mm] | 17:29 | 18:12 | 16:47 | 16:51 | 17:23 | 17:22 | 17:53 | 19:00 | 17:06 |

| Passengers per vehicle | Min [No. of pax] | 2 | 1 | 7 | 3 | 2 | 8 | 11 | 1 | 6 |
| Passengers per vehicle | Max [No. of pax] | 135 | 136 | 64 | 120 | 124 | 72 | 71 | 70 | 58 |
| Passengers per vehicle | Average [No. of pax] | 46 | 45 | 37 | 45 | 45 | 37 | 38 | 38 | 35 |
| Passengers per vehicle | Median [No. of pax] | 40 | 38 | 38 | 42 | 40 | 38 | 39 | 38 | 36 |

| Distance per passenger | Average distance per passenger [km] | 7.26 | 7.36 | 15.58 | 8.06 | 7.94 | 15.81 | 16.58 | 16.83 | 17.65 |

**Figure 14:** Results of parameter variation of fleet size 1,800 vehicles for 100% demand and trips not restricted to AD (parameter variation: max. detour coefficient and flexibility)
6. Findings

The model results show that implementing a flexible mobility service utilising autonomous vehicles is feasible, resulting in a fierce decrease in the number of vehicles needed to service the demand. Today in the AD 43,000 vehicles are registered. In the model applied for this study, about 5% of the previous vehicle volume would be sufficient for serving the demand.

The model results show a high mean value for vehicle mileage per vehicle and day. With around 330 veh-km per day, every vehicle could potentially cover around 100,000 km per year. This could lead to a potentially shorter lifespan for each vehicle, possibly needing repairs or replacements every other year.

Furthermore, the results show that carpooling can work, even in rural areas. Larger flexibility and maximum detour coefficient have a positive effect on vehicle utilisation. However, regarding the differences in the share of billable kilometres a high-quality SAV service should be offered with a maximum detour factor of 1.2 and flexibility of only +/- 10 minutes. Taxi services or services without detour cannot reach these pooling performances by far.

Utilising the increased pooling possibilities of 8-seated SAVs, it seems suitable for rural areas, requiring that a large part of the demand is covered with this mobility service.

Looking at the distribution of operating hours per day (in Figure 11), it is questionable if with more than 25% of all vehicles driving more than 8 hours, an operation with drivers could even be feasible. Especially as operating hours only depict the duration the vehicles are in motion, breaks not included. Daily, vehicles are in operation a lot longer than today’s private vehicles. Not considered in this study are service and cleaning times. With average operating hours of 6-7 hours daily, this does not pose a problem. However, this should be considered in a next step.

The model runs show that some vehicles are exhibiting a high daily mileage. These distances are larger than today’s average electric vehicle’s range. The current model does not account for battery capacity and charging duration. However, this information is crucial for the determination if an economically sound service would be possible.

It is very likely that the household survey does not cover all trips conducted in this administrative district and trip chains were not implemented in the survey. Additionally, the extrapolation towards a mobility demand for the year 2030 might be imprecise, and changes in behaviour can only be predicted to a certain degree. Therefore, trip demand and trip duration have to feature some inaccuracies.

The model does not incorporate an optimisation of vehicle allocation or the possibility to change passengers to a vehicle with a better fit after the vehicle has been set. Through an optimisation of all allocated trips, a lower number of vehicles might be achievable.

Lastly, the scope of this paper only covers trips inside the AD and to the major surrounding cities. Including all trips out of and back into the AD will lead to more complex traffic patterns, a different allocation of passengers to vehicles and probably to a larger vehicle fleet.
7. Future work

The limitations mentioned before are a good starting point for further research. Different parameter combinations need to be examined.

This study shows plausibly that more kilometres can be billed than are covered by SAVs. Economic feasibility needs to be examined with kilometre costs and possible production and operation costs.

As this study does not include an optimisation, different optimisation parameters need to be researched, especially with the optimisation of trip pooling through the dispatcher. Pooling could even be improved through different pricing schemes. As a large part of peak hour demand in the morning are pupils, these could be excluded or dispatched onto a scheduled line based service with feeder services.

For now, trips are scheduled at a fixed time before the requested starting time. However, this is not very realistic. A distribution should be incorporated into the request times in the model, even considering spontaneous requests.

However, most trips will most likely be reoccurring daily trips to and from work and to and from school, that could get optimised days before they actually take place.

8. Summary and Conclusions

Shared autonomous vehicles can not only be utilised in cities. SAVs can service the demand in a very efficient manner in rural areas, as well. This could decrease the number of cars in households considerably. Even though, additional demand will probably be induced, especially from those, who are not able to drive a vehicle themselves nowadays about 5% of today’s vehicle fleet could be sufficient to guarantee mobility for everybody.
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MaaS in rural areas - case Finland

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Abstract

The purpose of this paper is to present the special characteristics of rural areas for MaaS development, based on a project co-funded by the Ministry of Agriculture and Forestry of Finland. The paper presents rural mobility SWOT analysis and challenges, as well as goals and vision. Solutions for MaaS services in terms of collaboration, services & markets, planning & decision-making, and technology & information are proposed. The next steps to be taken in rural MaaS development are examined.

The population in rural areas is both decreasing and aging, dropping vehicle occupancy rates and creating greater demand for social and health service transportation. All this, coupled with tightening financial targets, long distances and narrow flows of people and material, creates challenges in organizing efficient mobility and transport services in these areas. The rural MaaS vision emphasizes well-being and accessibility with an appropriate level of service and cost-efficiency.

The collaboration of different stakeholders — businesses, the public sector and people — is key to the success of MaaS services in rural areas. New pilots with impact assessment should be carried out and best practices disseminated. The unique characteristics of rural areas should be taken into account in e.g. legislation and financing. Technology is an enabler of efficient MaaS services; thus digitalization of data and use of open/defined interfaces is recommended. A toolkit for MaaS pilot/service development is needed to promote the development and implementation of new MaaS services.

Several structural and legislative changes are ongoing in Finland. As the operational environment changes, services and stakeholders need to keep up. Rural areas have a major potential to organize transport services more efficiently. Better collaboration, more pilots, and an open mindset toward new services are needed to promote rural MaaS.

KEYWORDS Mobility as a Service, MaaS, rural, SWOT, vision
Introduction

Megatrends have an ongoing effect on transportation. Current megatrends include urbanization, climate change, globalization, digitalization and demographic shifts. Given that current transport systems are based largely on private cars and that urban areas are becoming ever more congested, new transport solutions are urgently needed to decarbonize these transport systems. Digitalization is one megatrend that is helping the transport sector find new solutions and bring greater efficiency and transparency to the transport system. (Pöllänen et al. 2015) In Finland, the current government program aims to promote the use of digitalization in the transport sector and services (Finnish Government 2015). Emission targets require a remarkable reduction of transport emissions. Necessary measures include improved energy efficiency of vehicles, new sources of low-emission fuel and power, and improved energy efficiency of the transport system by e.g. adopting new transport services (Aho et al. 2017).

Mobility as a Service (MaaS) is an emerging concept of new integrated transport services. According to the MAASiFiE project, MaaS is considered as “multimodal and sustainable mobility services addressing customers’ transport needs by integrating planning and payment on a one-stop-shop principle” (MAASiFiE 2016). Hietanen (2014) defines MaaS as “a mobility distribution model in which a customer’s major transportation needs are met over one interface and are offered by a service provider”. The European Commission (2016) considers that MaaS could offer travellers easy, flexible, reliable, price-worthy and environmentally sustainable everyday travel, such as public transport, carsharing, car leasing and road use, as well as more efficient goods shipping and delivery possibilities. The sharing economy is booming, and several types of sharing services in transportation already exist. Carsharing companies (e.g. DriveNow, ZipCar), peer-to-peer carsharing services (e.g. ShareIt Blox Car), ridesharing services (e.g. BlaBlaCar) and bike-sharing services (e.g. DB/DIMIS including car and bike services) are all part of the current trend (Eckhardt et al. 2017a). Ridesourcing services, such as Lyft or Uber, are most frequently used for social trips when public transit runs infrequently or is not available (SUMC 2016). There are also organized hitchhiking services, and e.g. Rezo Pouce was developed to assist with rural mobility (Rezo Pouce 2017).

MaaS is expected to have several positive effects on the environment, such as a modal shift from car to public transport and sharing services, an increase in multimodal trips, greater resource efficiency, and decreased emissions (Karlsson et al. 2017). The UbiGo MaaS trial in Sweden showed attitudinal changes toward various travel modes, participants becoming less positive toward the private car and more positive toward alternative modes like carsharing, bus/tram, and bike sharing (Sochor et al. 2016). MaaS can also improve accessibility to transport and have a positive impact on total travel cost per individual/household (Karlsson et al. 2017). Also, MaaS has potential to improve the efficiency of existing transport services and public resources (Polis 2017).
MaaS is often developed and studied from an urban point of view, with rural areas receiving less attention. However, in Finland and many other developed countries, large numbers of inhabitants still live in rural areas. Rural areas also cover large geographical regions as shown in Figure 1. In these areas, public transport coverage may be insufficient; thus MaaS cannot be based on public transport as in cities. Rural areas with sparse population, long distances, and low capacity utilization rates could improve efficiency by integrating different types of transportation (Eckhardt et al. 2017a). For example, a MaaS operator could, in addition to the

Figure 1. Degree of urbanization for local administrative units (Eurostat 2017)
mobility of people, include last-mile deliveries (parcel, post, shopping, pharmacy products and meal deliveries) and statutory social and health service transportation integrated with commercial services (Eckhardt et al. 2017a). Public-private collaboration and partnerships are recommended (Eckhardt et al. 2017a, Polis 2017, SUMC 2016). Polis (2017) states that MaaS requires stronger collaboration between the public and private sectors, and that new mobility services should be developed in collaboration with the private sector and local and transport authorities, supporting city and regional transport priorities and policies.

In Finland, the operational environment surrounding transport services is undergoing several changes including health, social services and regional government reform, and legislation covering the Transport Code and public procurement. Finland is characterized by its very sparsely populated areas with long distances to municipality centres, especially in areas such as Lapland, which has a population density of 180 000 inhabitants per 100 000 km$^2$ (Regional Council of Lapland 2017).

**Methodology**

The purpose of this paper is to present the unique characteristics of rural areas with respect to MaaS development, based on the project ‘Mobility as a Service Concept Promoting Service and Livelihood Development in Rural Areas’ (Rural-MaaS 2017). The project was co-funded by the development fund of the Ministry of Agriculture and Forestry of Finland and was conducted in 2016–2017. The project aimed at creating a national vision for MaaS in rural and sparsely populated areas. It focused mainly on recognizing emerging and potential business models for both commercial and publicly supported transport services. It also improved awareness of the MaaS concept in rural areas by sharing knowledge, and by providing measures and recommendations for developing mobility regulations and on the technical aspects of MaaS.

The Rural-MaaS findings and analyses are based primarily on qualitative data collected via workshops, interviews and a literature review. The paper presents SWOT, challenges, objectives and the vision for rural mobility. Solutions are proposed for mobility services regarding collaboration & combination, services & markets, planning & decision-making and technology & information. In addition, further steps for rural MaaS development are suggested.

Two regional workshops were organized in each of four regions: Lapland, Central Ostrobothnia, South Karelia and Southwest Finland. The first workshop concentrated on regional vision and the objectives of mobility services. There were three different perspectives on mobility services:

1. Business including tourism and last-mile deliveries.
2. Inhabitants who pay for their mobility services. This may be related to e.g. commuting, hobbies, and shopping journeys carried out by families and pensioners. The sharing economy was also considered, along with what services would be practical to bring to the customer and which services the customer would go to.
3. Publicly supported/subsidized transportation, including statutory social and health service transportation and school transportation.

Finally, the proposed ideas were prioritized and the most important presented in the second workshop. The workshop considered which actions and actors would be needed to reach the vision and objectives defined in the first workshop. The participants represented mainly regional and municipal authorities, social and health service stakeholders, local and rural development organizations and networks, transport services, mobile and ICT service providers, and the research community.
The project performed 30 interviews during the fall of 2016 and spring of 2017 with the organizations listed in Table 1. The interviews dealt with e.g. the current state (SWOT) and challenges (C) of rural mobility, possible mobility solutions, and business models. Also discussed were enablers, barriers and need for change regarding legislation. A literature review was performed to identify e.g. existing rural mobility services, pilots and solutions; nearly 20 cases were noted.

Based on regional workshops, interviews and the literature study, preliminary results were obtained which were then further developed, prioritized and validated in a national consolidation workshop. The rural mobility vision was also created as part of the consolidation workshop.

**Table 1. Interviewed organizations in the Rural-MaaS project**

<table>
<thead>
<tr>
<th>Organization</th>
<th>Ministry of Agriculture and Forestry</th>
<th>Regional Council of South Karelia</th>
<th>The city of Rovaniemi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Association of People with Disabilities</td>
<td>Centre for Economic Development, Transport and the Environment (ELY) of Lapland</td>
<td>Soite - Central Ostrobothnia joint municipal authority of social and health service</td>
<td>The council of rural policy MANE</td>
</tr>
<tr>
<td>Centre for Economic Development, Transport and the Environment (ELY) of South Ostrobothnia</td>
<td>Municipality logistics of Finland</td>
<td>South Karelia Social and Health Care District</td>
<td>The hospital district of Lapland</td>
</tr>
<tr>
<td>Centre for Economic Development, Transport and the Environment (ELY) of Southeast Finland</td>
<td>Petri Pekkala (trade name)</td>
<td>Tampere University of Technology</td>
<td>The hospital district of North Ostrobothnia</td>
</tr>
<tr>
<td>Finnish Transport Safety Agency</td>
<td>Posti Group Corporation</td>
<td>Technical Research Centre of Finland</td>
<td>The social insurance institution of Finland (Kela)</td>
</tr>
<tr>
<td>Growth Corridor Finland</td>
<td>Regional Council of Central Ostrobothnia</td>
<td>Association of Finnish Local and Regional Authorities</td>
<td>Tuomi Logistics Ltd.</td>
</tr>
<tr>
<td>Linna business development (Hämeenlinna)</td>
<td>Regional Council of Lapland</td>
<td>The city of Hämeenlinna</td>
<td>Uber Finland</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The city of Imatra</td>
<td>Visit Rovaniemi</td>
</tr>
</tbody>
</table>

**Rural mobility SWOT + Challenges**

The current state of rural mobility was analysed using SWOT + Challenges analysis. It aimed at clarifying strengths, weaknesses, opportunities, threats and challenges of current mobility services and in organizing them. To clarify the analysis, the results were divided into four categories: stakeholders, technology, operational environment & context, and services & market. Tables 2–5 show the main results of SWOT in these categories. Table 6 presents the main mobility challenges in rural areas.
Table 2. SWOT analysis of stakeholders (modified and translated from Eckhardt et al. 2017b)

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Decision-makers are aware of development needs: will, enthusiasm and</td>
<td>• Silo effect of stakeholders: decision-making, economic, legislation,</td>
</tr>
<tr>
<td>financial support of state and municipalities is extremely important</td>
<td>transport, planning collaboration</td>
</tr>
<tr>
<td>(health and social services require)</td>
<td>• Contracts and procurement: inflexible, traditional price competition,</td>
</tr>
<tr>
<td>• Kela: call center system for ride-sharing covers the whole country</td>
<td>short-term thinking, incompetence, lack of collaboration</td>
</tr>
<tr>
<td></td>
<td>• Lack of resources and expensive current system: subsidized transportation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Collaboration of municipalities, ELY Centres and social and health</td>
<td>• Reducing support and subvention</td>
</tr>
<tr>
<td>service/care actors and Kela</td>
<td>• Law reform (procurement law) leads to poor interpretations and solutions (partial optimization)</td>
</tr>
<tr>
<td>• Health, social services and regional government reform and changes in</td>
<td>• School transportation under the municipalities’ responsibility may</td>
</tr>
<tr>
<td>legislation enable reorganization of mobility services</td>
<td>remain separate from the entity</td>
</tr>
<tr>
<td>• Regional and inter-regional collaboration in mobility services:</td>
<td>• Transport Code will benefit large companies and small ones will lose</td>
</tr>
<tr>
<td>operative planning, procurement, best practices</td>
<td>out</td>
</tr>
<tr>
<td></td>
<td>• The needs of special groups cannot be taken sufficiently into account</td>
</tr>
<tr>
<td></td>
<td>• Large reforms and uncertain future → development stops</td>
</tr>
<tr>
<td></td>
<td>• Inefficient investment allocation</td>
</tr>
<tr>
<td></td>
<td>• Lack of collaboration and separate visions of stakeholders</td>
</tr>
</tbody>
</table>

According to the stakeholder SWOT, the consensus among decision-makers on the current status and need for development is a strength that facilitates the development of rural mobility solutions and procurement of the required resources and investments. Kela, which partially covers illness-related transportation based on the National Health Insurance (NHI), has call-centers for organizing transportation. The system enables ride-sharing and covers the whole country with a similar operational model, which is seen as a strength.

The main weakness regarding stakeholders is the silo effect within and between organizations. Removing this obstacle is probably of the main development needs facing rural MaaS. Collaboration at all levels on decision-making, economy, legislation, transport and planning, is needed to avoid partial optimization. Also, the lack of resources is a weakness that could cause incompetence and inflexibility in procurement and contract-related issues, at least to some extent.

The ongoing changes and reforms open up possibilities to take mobility into account and redefine the organization of transportation. Collaboration enables considerable possibilities for improving and creating new services, as well as raising the degree of efficiency and the service level in rural areas. Collaboration should take place at least between municipalities, ELY Centres responsible for organizing regional public transportation, and Kela (NHI transportation). Regional and inter-regional cooperation could enable e.g. common planning and procurement of mobility services, and information exchange regarding best practices.
The main threats are related to uncertainties due to current changes and reforms, and the lack of financial resources. Publicly subsidized transportation is a remarkable item of expenditure for the public sector, and there is pressure for economies. If changes to health, social services and regional government reform and legislation relating to e.g. the Transport Code, fail to remove or even end up increasing the silo effect, and if collaboration between different stakeholders does not succeed, partial optimization may remain in the future.

Table 3. SWOT analysis of technology (modified and translated from Eckhardt et al. 2017b)

<table>
<thead>
<tr>
<th>SWOT: technology</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Extensive infrastructure: ICT (developed), road network</td>
<td>• Lack of IT systems and information, accessibility and usability: broadband blind spots, communication between the public sector and consumers</td>
</tr>
<tr>
<td></td>
<td>• Digitalization: services, adopting, will</td>
<td></td>
</tr>
<tr>
<td>Opportunities</td>
<td>• The needed technology exists, is available and develops continuously</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Opening of data and connecting open data, use in decision-making</td>
<td></td>
</tr>
</tbody>
</table>

Technological strengths include highly developed and extensive ICT infrastructure. However, there are some blind spots in rural areas that create inequality. Digitalization is also recognized as a strength. The authorities have a common will to develop digitalized services, attitudes towards them are positive, and people are familiar with using them. Current digitalized mobility services include mobile ticketing and payment, (re) routing and other smartphone applications. Despite this, the transport sector has been relatively slow to exploit the potential offered by digitalization.

Technology and data are seen to enable collaboration and decision-making based on transparent information. Technology readiness is an opportunity, as the technology needed for new mobility services already exists. No technological threats related to rural mobility services were identified. However, general technological issues such as privacy and security affect all services.
Table 4. SWOT analysis of operational environment and context (modified and translated from Eckhardt et al. 2017b)

<table>
<thead>
<tr>
<th></th>
<th>SWOT: operational environment and context</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths</strong></td>
<td>• Local stakeholders and knowledge</td>
</tr>
<tr>
<td></td>
<td>• Stable situation regarding population and services, good predictability of demand</td>
</tr>
<tr>
<td></td>
<td>• Solidarity, spontaneity (e.g. associations, clubs)</td>
</tr>
<tr>
<td></td>
<td>• Active culture of experimentation and support of authorities</td>
</tr>
<tr>
<td><strong>Weaknesses</strong></td>
<td>• Concentration of business and residents to population centres</td>
</tr>
<tr>
<td></td>
<td>• Inefficiency: thin flows, long distances, low occupancy rates, mobility based on personal cars, seasonal changes</td>
</tr>
<tr>
<td></td>
<td>• Limited infra: poor condition of road network, poor coverage of rail network, accessibility of air traffic</td>
</tr>
<tr>
<td><strong>Opportunities</strong></td>
<td>• Possibility of an extensive rail network</td>
</tr>
<tr>
<td><strong>Threats</strong></td>
<td>• Condition and maintenance of the road network deteriorate</td>
</tr>
<tr>
<td></td>
<td>• Population is decreasing and aging in the countryside, urbanization</td>
</tr>
<tr>
<td></td>
<td>• Operational preconditions deteriorate → service level drops</td>
</tr>
<tr>
<td></td>
<td>• No new market-based services</td>
</tr>
<tr>
<td></td>
<td>• Change of generation → will entrepreneurship continue?</td>
</tr>
<tr>
<td></td>
<td>• Will people with limited means stay outside the services?</td>
</tr>
<tr>
<td></td>
<td>• People without a driving license (e.g. children, youth, elderly) are dependent on the mobility of others</td>
</tr>
</tbody>
</table>

In general, people in rural areas usually know and trust their neighbors more than those in cities do. This is also a strength regarding e.g. peer-to-peer services. They also know the special characteristics of their region and are often active in developing services there within associations, clubs etc. As the number of MaaS pilots increases, new services can initially be piloted on a small scale in rural areas.

The weaknesses of the operational environment of rural mobility relate to the characteristics of rural areas: low and sparse population, and long distances between people and services. This poses challenges to offering comprehensive mobility services and maintaining the infrastructure.

The rail network is considered a possibility, as smaller railway stations could be exploited to create travel chains to rural areas. However, many smaller railway stations are now either closed or trains stop there more seldom.

The operational environment of rural mobility services is challenging. Urbanization and a decreasing population lower the population density, at the same time that the population is aging and will probably need more health service transportation. These issues create even greater challenges to constructing efficient mobility services, maintaining an appropriate service level, keeping entrepreneurs, and maintaining the infrastructure in rural areas. Furthermore, the accessibility and equity of people with limited means or without a driving license, such as the elderly or youth, is a concern.
Table 5. SWOT analysis of services and market (modified and translated from Eckhardt et al. 2017b)

<table>
<thead>
<tr>
<th>SWOT: services and market</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sharing economy and peer-to-peer services: trust</td>
<td>Insufficient resources and expensive current system</td>
</tr>
<tr>
<td></td>
<td>Sufficient taxi fleet in each location</td>
<td>Conditions of commercial stakeholders in rural areas are more challenging</td>
</tr>
<tr>
<td></td>
<td>Subsidized transportation: creates basic transport load for the integration of other transportation</td>
<td>Service offering is limited and no competition (transport and other services)</td>
</tr>
<tr>
<td></td>
<td>Posti Group (Finnish postal service): distribution network during weekdays covering the whole country</td>
<td>Lack of travel chains and interoperability of modes</td>
</tr>
<tr>
<td></td>
<td>Combing rides and creating travel chains: mobility of people and goods, postal delivery, taxi, sharing services; combining stakeholders in social and health services/care, municipality, ELY Centre and Kela; ambulance buses for non-urgent transportation</td>
<td>Support and subvention is decreasing</td>
</tr>
<tr>
<td></td>
<td>Improvement of service level (accessibility) due to economies gained through combining transportation and technical solutions</td>
<td>Remarkable rise in costs</td>
</tr>
<tr>
<td></td>
<td>Bringing services to customers</td>
<td>Taxi services will drop, prices will increase, availability will decrease</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The Transport Code will benefit large companies and small ones will lose out</td>
</tr>
</tbody>
</table>

Regarding rural mobility services and the market, identified strengths include sufficient and available taxi services, extensive and regular postal services, and publicly subsidized transportation, together creating a solid core of transport that could potentially be integrated into new transport solutions. Also, trust between people in rural areas creates a good basis for establishing sharing services.

The challenging operational environment creates weaknesses in rural mobility services and the market. The current system offering publicly subsidized individual transportation is too expensive, making it unsustainable. On the other hand, due to the low volumes, completely market-based solutions are not realizable and subvention is needed to organize transportation. The small market in rural areas creates a shortage of services and competition, resulting in limited choices for users.

Opportunities are related to combining different kinds of transportation and services, as well as creating travel chains. This improves efficiency and brings economies, which is expected to improve the service level. The mobilization of services is also an opportunity to improve the service level. Services could be brought to users, either physically with e.g. library buses or virtually through technology.

The main threat to rural mobility services and the market is cuts to subvention. For commercial stakeholders this might mean higher prices, fewer service offerings and concentration to the most profitable services and areas. The principal aim of the Transport Code is to promote new mobility and transport services. However, liberalizing taxi services may have a remarkable effect on the availability and prices of taxis in rural areas.

In addition to the SWOT analysis, current challenges to rural mobility were studied and the main findings are presented in Table 6. Regarding stakeholders, the main challenge is the silo effect and too high a service level of publicly subsidized transportation. As several stakeholders are in charge of organizing them, it is challenging to find good solutions for the entity while taking reforms and legislative changes into account.
From the technological point of view, incompetence and lack of expertise is the main challenge due to lack of resources and possible resistance to change.

From the operational environment point of view, every stakeholder in the MaaS ecosystem does not necessarily share the same vision, and some are not as development-oriented as others. Demand is not stable, due to school holidays and other seasonal transport needs. When there are too few users to maintain the core transport, offering transport services is challenging.

Inequality between freight and mobility services, e.g. related to infrastructure investment, is challenging for mobility services and the market. Lack of customers in rural areas, especially outside working hours, results in a limited market and services. From the user perspective, accessibility might be problematic especially for special groups. For example, accessibility to a bus might be good in the city but poor when arriving in a rural area. The tendency to centralize services (e.g. healthcare) in order to gain economies causes a rise in transportation needs and costs, as well as in emissions. Thus, partial optimization is a major challenge.

Table 6. Current challenges to rural mobility (modified and translated from Eckhardt et al. 2017b)

<table>
<thead>
<tr>
<th>Current challenges to rural mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Actors</strong></td>
</tr>
<tr>
<td>The silo effect of publicly subsidized transportation</td>
</tr>
<tr>
<td>Unclear cost sharing between responsible stakeholders</td>
</tr>
<tr>
<td>No stakeholder responsible for developing and coordinating mobility services in municipalities/regions</td>
</tr>
<tr>
<td>Challenging to identify good service combinations also from the society’s point of view</td>
</tr>
<tr>
<td>Incompetence and lack of expertise in organizing and planning mobility (tendering, IT)</td>
</tr>
<tr>
<td>Health, social services and regional government reform and the Transport Code create uncertainty that will complicate the development and combination of publicly subsidized services, at least until the end of 2018</td>
</tr>
<tr>
<td>Expenses of publicly subsidized transportation are unsustainable</td>
</tr>
<tr>
<td>Too high a service level when considering the system as an entity</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
</tr>
<tr>
<td>Incompetence and lack of expertise in organizing and planning mobility (tendering, IT)</td>
</tr>
<tr>
<td><strong>Operational environment and context</strong></td>
</tr>
<tr>
<td>Lack of a common will and rules</td>
</tr>
<tr>
<td>Slowly changing attitudes/unwillingness toward new solutions</td>
</tr>
<tr>
<td>Irregular transportation demand (e.g. school transportation, seasonal changes)</td>
</tr>
<tr>
<td><strong>Services and market</strong></td>
</tr>
<tr>
<td>Freight/business goes first (e.g. infra investments)</td>
</tr>
<tr>
<td>Restricted market</td>
</tr>
<tr>
<td>Poor service level of public transport</td>
</tr>
<tr>
<td>Evenings and weekends have an even poorer service supply</td>
</tr>
<tr>
<td>Public transport does not fulfill accessibility requirements</td>
</tr>
<tr>
<td>Centralized services may lead to growth in transportation (partial optimization of costs, environmental aspect)</td>
</tr>
</tbody>
</table>
Rural mobility vision and objectives

The Rural-MaaS project defined the rural mobility vision as: “Ensure for everyone adequate mobility services and accessibility relative to well-being, cost-efficiently with an appropriate service level” (Eckhardt et al. 2017b). Other important aspects of the vision include maintaining the vitality of rural areas and offering reasonably priced services to everyone regardless of their place of residence, as mobility is a prerequisite e.g. for healthcare, business and accessibility.

The main objectives of rural mobility are presented in Table 7. Combining publicly subsidized transportation improves efficiency. This applies to hospital districts (between hospitals and other health centers), Kela (in case of illness) and municipalities including e.g. school transportation and social and health services (e.g. the elderly, disabled). The current system offers too high a service level in some parts, which could be adjusted to a more appropriate level. The connection between municipal/regional and national level development would ensure the implementation of a national transport strategy, as well as uniformity and interoperability between regions.

Transport service centers for publicly subsidized transportation could be utilized to offer services on a one-stop-shop principle, for which technical interoperability and integration of actors and transport modes is essential. The aim is to increase the use of ride-sharing, public transport (also as an on-demand service), travel chains, and autonomous driving in the future. Accessibility to all user groups is important. More extensive rural mobility pilots are needed to find good solutions and to share best practices.

Table 7. Objectives of rural mobility (modified and translated from Eckhardt et al. 2017b)

<table>
<thead>
<tr>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Collaboration and combination</strong></td>
</tr>
<tr>
<td>• Combining publicly subsidized transportation (social and health services/care, Kela, municipality)</td>
</tr>
<tr>
<td>• Utilizing transport service centres</td>
</tr>
<tr>
<td>• Developing travel chains (flexibility, ease)</td>
</tr>
<tr>
<td>• Connection between national and municipal/regional level development</td>
</tr>
<tr>
<td>• Adequate service level considering the system as an entity</td>
</tr>
<tr>
<td><strong>Services and market</strong></td>
</tr>
<tr>
<td>• Accessibility of mobility is important for parity (taking special groups and people without a driving license into account)</td>
</tr>
<tr>
<td>• Transport services for all and on a one-stop-shop principle</td>
</tr>
<tr>
<td>• Developing the attractiveness of public transport (bus, train…); on-demand (and autonomous) transport</td>
</tr>
<tr>
<td><strong>Technology and information</strong></td>
</tr>
<tr>
<td>• Interoperability and integration of stakeholders and transport modes (one-stop-shop principle)</td>
</tr>
<tr>
<td><strong>Research and development</strong></td>
</tr>
<tr>
<td>• More extensive pilots</td>
</tr>
<tr>
<td>• On-demand (and autonomous) transport</td>
</tr>
</tbody>
</table>
Potential solutions for rural MaaS

Collaboration and combination

Collaboration is needed between municipalities, social and health services/care, ELY Centres and Kela, and collaboration by the public sector should be made mandatory. Transport services should be analyzed by taking the entity into account. Combining the services would require a national system or database where all the relevant information is available to the stakeholders involved. Also, the collaboration between the public and private sector and people (PPPP) is necessary. The collaboration could also be international.

Interoperable payment and ticket systems are a necessity for fluent collaboration and combining transport services. A typical service level should be agreed upon jointly, as well as delivery frequencies and destinations. Then procurement tendering could be performed aiming at overall efficiency and innovative approaches.

Different transport services, such as individual transportation, group transportation and last-mile deliveries should be combined. Services should be open to all, and publicly subsidized transportation could be available to anyone on public transport fees, for example.

Mobility services should be included at strategic level, and in the development projects of municipalities, which would avert a silo effect or optimization of a single viewpoint. For example, there could be changes in school schedules when taking the transportation entity into account.

Services and market

Transparency and synchronization of demand and offering are essential; they would enable on-demand transportation and the use of suitable vehicles, leading to e.g. savings in resources. In addition, real-time transport information can assist in data visualization, which can contribute to a meeting of demand and offerings. Mobility service shops and platforms include the routes, schedules and prices of services. Solutions need to be easy to use and adopt. Publicly subsidized transport would have access to comprehensive customer profiles including special needs (e.g. disabilities). Service classes with time windows could be created based on urgency. In order to create travel chains, concrete tools and applications are needed, including schedules and purchasing possibility.

For public administration, mobile service vehicles could be established for pupils and residents. Offered services could include e.g. health nurse services, diabetes counseling and dental care. Mobility services based on sharing economy create new possibilities to develop mobility, especially in rural areas where public transport is limited. Currently, transport is the second biggest cost item for households, but private cars are in use only some five percent of the time, averaging roughly 1.5 passengers per time. Digital solutions for sharing economy are one way of increasing occupancy and utilization rates of vehicles, and creating an interesting option to public transport where accessibility is poor.

Planning and decision-making

Combining the mobility of people and goods should be widely enabled. Legislation and decision-making that support mobility services are needed, as well as transparent procurement. Innovative procurement is recommended, as it concentrates on problems and objectives instead of a predefined solution.

Related to publicly subsidized social and health service/care transportation, the possibility of a personal mobility budget should be studied. The user would have more flexibility to organize transportation based on individual needs and preferences within the budget allocated according to the extent of support needed.
However, how to encourage car- and ride sharing needs to be solved. Also, sufficient information on the number of customers and their mobility needs would be required for organizing and procuring the services. The service level does not necessarily have to be the same in all areas. For example, kilometer-based zones with different service levels would mean that a municipality, when granting building permits, could tell which subsidized mobility services are available in that zone. The most rural areas do not necessarily have to have the same services as areas closer to a municipal center.

The capacity of private cars (including cars owned by municipalities and companies) could be exploited in sharing services. Air traffic should be analyzed based on the number of passengers and demand. For example, some airports could remain open only during the peak season and when there is sufficient demand. When they are closed, transit could be organized from other airports to these areas. Commuting should be taken into account related to schedules and park and ride. The pricing logic also requires development. For example, how to assign a price if a taxi ride includes both people and a parcel?

Technology and information

Informing the public about mobility services is a priority. General information is needed on the availability of services and their content, but also with a view to changing attitudes to new services. It is recommended to create a safe and secure payment system where charging and possible reimbursement would be dealt with afterwards in the most economical way for the customer. For example, if only a few trips are made per month, the fare could be based on single tickets. If there are many trips, a monthly fee could be charged instead. Payment could be by credit card, or by identification and the background system would take care of charging. IT know-how should be developed on a practical level among different stakeholders, such as municipalities and transport operators etc.

Conclusions

In Finland, several structural and legislative changes will affect rural transport in the near future. These include health, social services and regional government reform and changes in legislation such as the Transport Code and public procurement legislation. There are also several other types of legislation affecting transport services in rural areas, and these should be analyzed as an entity. The legislation is also open to interpretation, which is why it should be easy to understand and guidance put in place for its application.

Changes in operation models, as well as roles and responsibilities, require efficient collaboration and a common will to achieve effective and user-oriented mobility services in rural areas. Collaboration between different stakeholders — businesses, the public sector and people — is needed in addition to that between various levels of administration at national, regional and municipality level. As the operational environment changes, services and stakeholders need to keep up. Legislation should also guide and encourage stakeholders to collaborate.

New pilots with impact assessment are needed, as currently there is not enough quantitative data on rural MaaS to support decision-making. Studies and pilots also assist in defining the roles of related actors. As the legislation is still under preparation, it is still possible to affect the organization of publicly subsidized and commercial services and promote best practices identified in the pilots and services. Best practices should also be widely disseminated. A toolkit for MaaS pilot/service development is needed to support the development and implementation of new MaaS services. In addition, training related to changes in the transport sector is required for the public sector and service providers.
The particular characteristics of rural areas need to be taken into account in national development activities. This refers e.g. to legislation and financing regarding e.g. research and services. Technology is an enabler of efficient MaaS services. Thus digitalization of data and utilizing open/defined interfaces is recommended.

The equality gap between rural areas and cities may increase in the future. Measures to maintain lively rural areas in ways that are both resource- and cost-efficient should be sought. However, the possibility to create zones for different service levels should be examined in terms of land use, planning and construction. There is little competition in rural areas, which is challenging for business. Companies need to explore possibilities, change patterns dynamically along with changes in the operational environment, and join MaaS ecosystems (partners, networks). The sharing economy (i.e. cars and rides) is expected to take off in the near future. Services provided by private people would complement other services offered in rural areas. Rural areas have great potential for organizing transport services more efficiently through collaboration, open-minded development and innovative solutions.

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Opportunities of MaaS in US and rural areas

NIELS TVILLING LARSEN & CHARLOTTE FREI DemandTrans Europe

The challenges of urban and rural transportation are well catalogued, and only in the last several years with the proliferation of the smartphone and sharing economy have customer expectations and experiences begun to shift in a way that enables new opportunities for mobility providers. With the increased customer adoption of shared mobility, we now have an unprecedented ability to influence individual transportation choices and behavior for the better. At the same time, gaps in public transportation services, especially in the US, are creating pressure to develop easy-to-use demand-responsive systems that provide flexible alternatives. Such alternatives benefit from consistency in vehicle supply so that everyone, regardless of physical ability, has the opportunity to move throughout their community. Flexible services thus serve as a micro transit “glue” that can provide consumers with increased confidence in public transit while incentivizing decreased private auto use. This adaptation of attitudes (towards reliance on transit as need for one’s automobile decreases) makes microtransit an effective means to scale transit services as demand varies over time and space while also providing the opportunity to offer door-to-door service where appropriate.

Figure 1. The necessary steps to implement MaaS

The implementation of dynamic services in a larger MaaS framework needs to be an evolution, not a revolution. MaaS implementation needs to be led by progressive agencies and providers to move ahead in a new era of mobility freedom. Figure 1 shows a roadmap that we have for how a MaaS technology and providers system can scale from a simple set-up to a complete seamless platform. It’s a journey to come from the MaaS apps we know today, which primarily show many different service offers to an integrated platform with many coherent services that share the same payment and information system. An advanced mobility platform is a prerequisite for creating an app where the rider can seamlessly switch among different services from many suppliers. It is a maturation process where everybody has to pass through the various steps and where everyone has to learn about the possibilities and change of behavior - both the riders and providers of transport services.
Prerequisite for an open MaaS is a common traffic model with geographic descriptions

The “glue” that can make these traffic components work together and be a real alternative to a car is flextrafik in Danish, or Demand responsive transportation (DRT) in English. In its simplest form it allows smaller vehicles controlled by online real-time dispatch to be accessible directly to customers on-demand. In effect, it is these transport services that ensure that we can accommodate a more user-centered mobility paradigm and support door-to-door or “pop-up” location transport service anytime, anywhere. Previously, the main problem in integrating public transit was that these flexible services were invisible in that they were not shown in consumer travel searches for bus or rail services. Since real-time access to flex services is the glue that binds the MaaS experience together, a MaaS platform integrated with dynamic mobility services, which enables travelers to make a new choice with each and every trip - a choice to “switch” from driving to one of many convenient, demand-adaptive alternatives as the conditions warrant.

To make this work, there is a need for a common method of communicating and showing which services are available and at which times. In the fixed-line-based traffic, GTFS is used, but the community led by Aaron Antrim are still working on GTFS-FLEX to create a common industry standard to show accessibility to these services.

Demand-responsive transportation (DRT) Maturity

The Demand-responsive transportation (DRT) is also a rapidly growing subset of passenger transportation due to growing use of paratransit services. The paratransit services performed by demand- responsive transportation can be grouped as follows:

- Special needs transport for disabled and elderly, medical and other mobility services with a special permit to travel
- Open/public flexible transport for all user groups, can be intermediate
- Public Transport services in urban areas or rural transport with taxi/minibus, as replacement for large busses.
- Integrated DRT transport is a combination of special needs and open services and/or when DRT is used as feeder service to regular transit line (first/last kilometers).
The success of creating profitable (or less subsidized) flex service is to get the many services integrated and it requires maturity in the building of service, organizing and efficiently deploying mobility capacity through a comprehensive platform like MobillityDR.

The goal is to pool capacity from multiple vehicles including taxis, buses, shared-ride vehicles, and specialized accessible vehicles for those with mobility impairments in order to provide consumers with the freedom of mobility they desire and deserve, by creating a robust supply of vehicles for carrying out the transport tasks. By mixing the tasks with the scheduled transport and the individual variable transportation, we get better opportunities for planning. As Figure 2 shows, it is a decisive factor in efficient allocation of available resources to meet changing needs. It is essential to balance the supply and demand, since the model is otherwise not sustainable.

Experience from many small scale experiments that have attempted to grow without sufficient IT support tools demonstrates that a well-designed IT platform is crucial to ensure scalable and smooth operations. For a well-designed IT platform to function, it is crucial that there are consistent transactional data specifications among providers. The transactional data contain information that allows for requested trips to be assigned to one of several service providers suppliers; such specifications are a prerequisite for collaboration and the ability to mix different transport services on the same vehicles. One initiative that has implemented transactional data specifications in practice is the transactional data standard used in Scandinavia, known as SUTI (Standardiserat Utbyte av Trafik Information). There is a need to develop and adopt a common international standard, not only drawing lessons from SUTI to make it applicable internationally, but also improving upon it.

Business Models for MaaS setup.

The starting point for creating a sustainable MaaS system is an open ecosystem with (1) a standardized integration API, (2) open access for all providers and (3) easy access for riders to use services. The open access makes it impossible to generate revenue by limiting access to the platform, but there are three principal self-sustained models to finance, control and run an open platform for MaaS:

1. A public transport authority takes responsibility, manages and pays the operation of the platform,
2. The riders pay by a monthly subscription, and earnings from payment transactions controlled by a platform provider, or
3. A broker handles the platform and takes a cut from the service providers.

All three models have considerable inconvenience. The first model requires a significant public investment and public management usually removes agility. The second model has the problem that it requires a large-
scale commitment from riders to a setup that may lead to higher ticket prices to pay for the platform. The third model requires that service providers can get access to customers at a lower cost than normal, to have an incentive to pay for this service; however, this is only the case when there are many customers in the system, which first comes with an expanded service offering.

The lack of self-sustainability of a MaaS model means that it is necessary to find an “external” funding for such a setup. The funding can come from savings on paratransit trips in the special area - but this can only occur in a state of integrated DRT, in which all demand driven traffic is coordinated, ensuring maximum utilization of vehicles. This means that a MaaS setup also needs to integrate ADA compliant service, Service for Disabled, local municipal service, taxi service, seniors transport services, and non-emergency medical transportation.

This also means that there will also be access to vehicle resources in the form of City ADA compliant service, Taxi ADA compliant service, Local MVP Customers and Private ADA compliant drivers and vehicles.

The basic concept successfully used by FlexDenmark was to leverage technology to aggregate community ADA-compliant capability to improve efficiency and access while reducing costs, all of which is possible when the journey is described via a common standard. When the journey is correctly described, it is possible to consider multiple transport options because not everyone has the same special needs. The ability to receive trips from many sources with different service levels is essential for creating a sustainable setup.
Case from Denver

Generally, demand-responsive services have had a high cost per trip, but with DemandTrans’s automated system, there is no need for dispatchers and the driver’s job is simplified, thereby significantly reducing labour costs and creating realistic operating possibilities for automation of ordering and planning transportation to reduce unit costs. MobilityDR has been in use in the Denver region since 2009 for the Regional Transportation District’s general public DRT services operated in 22 service zones. The DRT services are a combination of first mile/last kilometer access and local circulation. The setup is totally automated by a standardization of concepts and interfaces. It is not a theoretical opportunity but a tried-and-tested solution in operation for nearly ten years.

The Denver case demonstrates the realistic operating possibilities for automation of ordering and planning transportation to reduce unit costs and make DRT a cost-effective part of the transport network - even before we have autonomous vehicles. The standardization of interface and transaction data also makes it an ideal service for joining a MaaS setup, and an early candidate for service production with an autonomous vehicle.

The ideal state of a MaaS
To ensure the glue holds in this setup, it is critical to have a shared DRT IT system, with one facilitator in each geographical region supporting numerous online ordering streams and multiple providers. The IT system works as a real-time marketplace system for all passenger transport services. This multimodal approach to transport provides access to the relevant transport service in relation to needs and possibilities. It also automatically combines different trips from many different transit systems with multiple optimization logics, and with different service needs and requirements. Each trip is described with all of its needs, requirements and flexibility (or lack thereof). The key to get all these different payers to participate in collecting these tasks is using a cost allocation model to ensure everyone pays a fair share of the costs to the provider. This level of coordination -- in a highly fragmented market undergoing rapid technological change -- will require organizational leadership to bring the right players and appropriate elements to the table.
BUSINESS 1

Worldwide business cases
The worldwide business case of MaaS Global

SAMPO HIETANEN MaaS Global, Finland

Presentation of the status of the worldwide business case of MaaS Global.

No written submission
The business case for Tuup MaaS and Kyyti

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People’s mobility needs have always been flexible and individual while public transport system has been based on fixed routes and timetables. Individual service has been served by taxi, which does not allow sharing the cost between the customers. Often the transport operators and authorities have also been forced to offer a minimum service level in the areas where mass demand does not exist with vehicles that are not suitable for the purpose and carry a high cost of operating. Different kind of ride sharing services have been used, but without compliant technology they have been ineffective and not real time. New technology enables meeting the flexible demand by using the capacity effectively to offer on demand services where the vehicle size is suitable for the purpose and service level is high because of the automated real time fleet management and demand pooling capability. This paper shares the first findings about the Kyyti taxi sharing business case. Kyyti is integrated to Tuup mobility as a service application, both launched to public in Finland. Most of the Kyyti’s early commercial data is still sensitive, but I will try to share some general findings, hoping they are useful.

Tuup maas application

Mobility as a Service (MaaS) is based on the idea of offering consumers a wide range of mobility alternatives, motorized and non-motorized, all easily accessible. Tuup MaaS is such an application. It makes route planning, comparing different mobility services, including one of the firm’s own design, and payment of these services, easy and seamless.

Tuup is a multimodal mobility application. Multimodality traditionally means making one journey by using more than one mode of transport – a travel chain in practise. Modern definition of multimodality is freedom of choice depending on customer’s need in each specific circumstance. Travel chain is one case of multimodality. Tuup integrates different kind of mobility services into one easy to use mobile application to help the customer to find the alternative most suitable for the particular need just this moment.

So far Tuup has developed an application, which has route and real-time timetable information for Finland. This App has timetable and route info for every bus and tram stop in Finland and information about several other mobility services, for example, real-time availability of citybikes at each dock in Helsinki. This App is useful to the customers as a planning tool as more than 40,000 downloads prove, but as a Business to Consumers (B2C) business case Tuup is still at product development level.

Making a Business to Consumer (B2C) business case out of a MaaS application needed integration to mobility service providers’ sales systems. Tuup has integrations to city public transport ticketing systems in Finland, but sales have been marginal so far. City transport authorities in Finland are, at the moment, not willing to pay commission on tickets sales, so there cannot be business opportunity for third parties on simply selling the public transport tickets to consumers. New Transport Code legislation will require all transport operators in Finland to open their single ticket sales APIs in 2018, but this alone will not create a market unless there will be understanding of the value of a sales channel. Legislation cannot dictate the commercial arrangements between the parties and if public transport authorities view on not paying sales commissions does not change, business needs to be found on creating extra value for the customer by bundling the services and charging service fees for doing so.
Tuup has obtained such extra-value revenue from tailoring a service to a car manufacturing company Valmet Automotive (VA). VA has a production plant 60 km away from the city of Turku. They were willing to provide their employees subsidised tickets for a bus service between the plant and Turku. Tuup developed a capability to recognise a customer group i.e. the VA employees, and to sell them tickets on a subsidised price. This bus service is also available for the public. Price for the VA employees is four euros, for others fourteen. The bus service has been highly popular and capacity of a standard bus is often not big enough for the demand. The Business case terms between Tuup and VA were development cost plus commission on the tickets sold.

Tuup has signed one material contract in the US, which cannot be published yet when writing this, and is participating on several other RFPs together with US partner DemandTrans. Tuup and DemandTrans have formed a joint venture named Switch, which will be operating primarily in the US and Canada but also globally when joint product offering is suitable. Tuup’s role in the joint venture is to provide the customer interface and service and payment integration capability. Where DemandTrans flex service modules can be complemented with Kyyti ride sharing technology modules, Kyyti will be offered as a part of Switch product offering.

Our finding at the early stage of the MaaS market has been that revenue can be made offering solutions to corporations, transport operators and transport authorities. Comprehensive understanding of the transport industry is a key factor in this market. How B2C market will evolve and what business models will be viable remains to be seen later.

**Kyyti ride sharing**

Tuup chose to enter the market by introducing Kyyti taxi-pooling service, situated between traditional public transport and taxi. Kyyti operators are licensed taxi or minibus operators. Kyyti technology can be used to complement or replace public transport and to create an appropriate service level in the areas where traditional public transport cannot operate effectively.

Kyyti is a real time, door to door, fully automated ride sharing solution. In B2C taxi-pooling service, fleet-level route optimisation is combined with a business model which encourages customers to be flexible about the waiting time or to allow longer driving time to have a more attractive price. Service can only be accessed by mobile app, but Kyyti has an open API for locations where there will be competitive MaaS operators.

Kyyti is aggressively priced and offers three service levels:

- **Express** is taxi-like direct service, but allows for minor route deviation to pick up or leave other passengers. Express is cheaper than traditional taxi service.
- **Flex** is more affordable. Passenger allows for some flexibility in both waiting and driving time.
- **Smart** is the most flexible and cheapest.

The idea behind three service levels was to give the customer a flexible enough variety of choices to be able to choose the level best suiting the different use cases. Level of flexibility can differ a lot between different situations. Sometimes it is important to get the taxi ASAP, sometimes it really does not matter. Even the Express service is cheaper than the taxi and Smart can be even cheaper than the public transport single ticket.

In the beginning, when the Smart service was priced highly aggressively for promotional reasons, even 2/3 of the demand was Smart level. After the promotion the pricing was adjusted and the gap between the
levels narrowed. Following table shows the distribution between different service levels after the promotional phase. Since the information is sensitive, we cannot reveal the period from which the following table is, but the time period was long enough to have statistical significance.

<table>
<thead>
<tr>
<th></th>
<th>Trips</th>
<th>% of Trips</th>
<th>Avg. Distance</th>
<th>Avg. Party Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart</td>
<td>8440</td>
<td>51.69</td>
<td>5.88</td>
<td>1.67</td>
</tr>
<tr>
<td>Flex</td>
<td>2965</td>
<td>18.16</td>
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<td>1.79</td>
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<tr>
<td>Express</td>
<td>4922</td>
<td>30.15</td>
<td>5.52</td>
<td>2.15</td>
</tr>
<tr>
<td>Total</td>
<td>16327</td>
<td>100</td>
<td>5.94</td>
<td></td>
</tr>
</tbody>
</table>

Kyyti was launched in Oulu, Finland, at the end of March 2017 and expanded to Turku and Tampere in June. Unfortunately we cannot open more details, but the only significant difference between the three cities in key indicators was the average distance being significantly shorter and average price lower in Turku than in other cities, which is an obvious outcome of the smaller operating zone.

The Kyyti-business model is commission on sales. Kyyti does not own the fleet nor operate it. Kyyti is a sales channel and scheduling and dispatching system, actual taxi-operation is operated by existing legal taxi/minibus operators. From the taxi operator’s point of view, the sustainable model must provide better overall revenue resulting from more effective use of capacity.

**Capacity is the key**

At the moment in Finland the number of taxis is still regulated. This will change in July 2018 when the new Transport Code comes into effect. Until then we will be forced to operate on non-ideal capacity which prevents the service from scaling up effectively. Flexible capacity is imperative for Kyyti-like service. Following is a snapshot from our log showing the “errors”. Basically all the errors are defined as rejections due to no capacity available, meaning that the service order was not inserted, because all vehicles were occupied.

We have had feedback from the customers, that the service is so seldom available, that they are no longer going to use it. This will be the case until the taxi market is deregulated. Meeting the volatile demand with dedicated capacity in a way that is commercially sustainable, is simply not possible. In practise the fleet size must be determined by the low demand instead of the peak demand.
Our finding about Kyyti has so far been that people really like the service for several reasons. Affordable pricing, modern technology and social aspect of sharing the ride are the factors that please the customers. Simplifying the offering by reducing the number of service classes from three to two has been the customer feedback and the statistics prove that there is only little demand for the flex service level. To improve the customer experience and usability, we have decided to launch a Kyyti app which has been specially designed to order Kyyti. Original approach was to offer Kyyti only as part of Tuup’s MaaS offering, but we have learned that it is not the most convenient way for the customers who only want to order Kyyti.

The capacity problem is yet to be solved. Kyyti needs flexible capacity to scale up. In the future market, same operators will take orders from several channels which gives them better effectiveness and us the flexibility to meet also the peak demand. We are also negotiating to provide Kyyti-enabled vehicles to replace publicly funded operations at their low demand times and locations, in a way that evens out the demand peaks for both, to the benefit of both the rider and the taxpayer.
Mobility as a Service (MaaS) as a concept has emerged over the last few years and is now being developed around the world. Global trends such as a desire for personalization and smart technology have driven this change and transformed the transport and mobility market from an operational to a service model of delivery. Future mobility services will need to be user focused, seamless and valued by the customer. This is disrupting the market and releasing new opportunities for companies and public agencies.

MaaS requires a number of products and services to come together within an eco-system. Scotland has expertise and experience in the key areas of energy, ICT and transport systems and has a number of large companies and SMEs offering new and exciting products. It has a supportive Government infrastructure and is the right size to offer companies the ability to trial MaaS products at a suitable scale before going global.

To this end Scottish Enterprise has supported, over the last 4 years, the development of a Scottish MaaS Alliance, now known as Mass Scotland (MS). MS comprises over 50 companies and public organisations, from global players to small SMEs, operating along the MaaS value chain. MS includes all the Regional Transport Partnerships, Transport for Edinburgh, Strathclyde Passenger Transport Authority and the Scottish Cities Alliance. MS is in partnership with the Scottish Government, Transport Scotland, the KTN and the Transport Systems Catapult and has members from out with Scotland including Nexus, in the north east of England. MS is hosted by Technology Scotland partnered with Scotland IS. These two trade networks cover the hardware and software skills and products through the MS network that MaaS needs. MS is also linked to the universities/R and D network.

The presentation will give a brief summary of the development of MaaS in Scotland.

MS is developing a number of MaaS Phase 1 projects in Scotland demonstrating how MaaS can be delivered in a range of situations. These trials are in partnership with the Scottish Government, Transport Scotland and local authorities. These projects will demonstrate how MaaS can be delivered in urban and rural areas and how it can be linked to other areas such as tourism and health. The projects will also seek to develop a commercial model that incorporates social and environmental objectives. The projects are at various stages of development and we are in discussions with the Scottish Government as to which projects should be delivered first. The projects are:

- Dundee Mobility Integrated Living Laboratory (MILL) – a large city region project.
- Perth and Kinross Council with Stagecoach and Hiya car – a small city/rural project.
- Navigogo – a MaaS package specifically for young people. Viaqqio, part of the ESP Group, who is leading this project, is also developing packages for those living with dementia and also living with cancer.
- Cairngorm National Park with Inverness – a project looking at a MaaS package that works with tourism in a national park linked to a small city.
- The Orkney Islands MaaS system – a MaaS eco-system for the Orkney Islands in the north of Scotland.
- Ardrossan to Isle of Arran – a MaaS package centred around a ferry service linking to bus, rail, car, car hire, taxi, e-vehicles and cycles.
• Stirling Council MaaS system – a small city/rural project.
• Connected Highway system with Transport Scotland – looking at a major strategic road using MaaS to provide a service to locals, tourists, freight and other businesses along the corridor.
• Edinburgh City Council and Edinburgh Centre for Carbon Innovation – project looking at the digitalization of mobility services to provide a MaaS system to users that also reduces reliance on carbon.

The presentation will give more details on these projects and update the conference on progress.

MS has forged strong links with other MaaS networks in Europe, specifically Finland and internationally with the USA, Canada, Australia and New Zealand. It is also in discussions with Travel Spirit in Manchester and Transport for West Midlands/MaaS Global in Birmingham. MS is a full member of the European MaaS Alliance giving MS members access to the services this growing pan-European network offers.

MS is also discussing the national framework within which MS and these projects sit. Part of this is the role of government, both central and local, the management and ownership of data, the role of regulation and legislation and the integration of the commercial model with the economic, social and environmental needs of communities. The presentation will give details on where we are with these discussions.
BUSINESS 2

Business enables
FluidHub – The Connecting Piece within a MaaS Ecosystem.

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ABSTRACT
To foster local MaaS initiatives and to define an ecosystem with clear stakeholder functions, a cloud-based service solution, called FluidHub, is introduced in this paper. FluidHub makes the large variety of mobility services accessible to Mobility Service Providers. It handles the integration of and contracting with Transport Service Providers and Enabling Service Providers (routing, payment) in order to support the development of an intermodal MaaS solutions, that is ready for a full-service roll-out in cities or regions. With FluidHub as Platform Service Operator, an innovative approach to deal with stakeholders’ needs and expectations within a MaaS ecosystem has been found. Additionally, the approach will be emphasized by presenting some real-time examples in this paper.

KEYWORDS Mobility-as-a-Service, integrated mobility, MaaS ecosystem, intermodal travel, consumer-centric, mobility needs, mobility platform operator

INTRODUCTION
In cities and urban areas with constant population rises, numerous people are moving through the streets every day. More and more transport services enter the market, to give people access to a wide range of mobility services like car sharing, bike sharing, taxi services or ride sharing as a supplement to public transports. At the same time, Mobility Service Providers – either Transport Service Providers that offer services via apps, private companies or municipal institutions – provide apps for e.g. traffic information, routing, parking or payment that still operate independently and are rarely exchanging information. From the overflow of separate information and various offerings arises the residents’ need for clarity and reduction. They demand for more and better-connected mobility apps. To manage the increasing mobility needs of citizens and to ensure more stability and smooth functioning of the mobility market, an interaction between all stakeholders within one city or region is required.

An innovative approach to deal with today’s transport challenges in urban and rural areas, to manage travelers’ need and to ensure more stability and smooth functioning of the urban mobility market, is to consider mobility as a service (MaaS). Being at an early stage with less experience and mostly no comparative results, Mobility Service Providers work on the development of intermodal mobility solutions that make a wide range of urban mobility options available and bookable to urban travelers. Despite initial success with first MaaS pilot projects, less MaaS services have been introduced to the market so far. This absence is essentially attributable to two barriers: the uncertainty of tomorrow’s role of stakeholders and a viable business model. In this paper, we introduce the approach to overcome these issues and foster local MaaS initiatives to establish a seamless and more sustainable way of transport.
MODEL SETUP

Our approach is based on the assumption that cities and regions, provider of mobility services, different modes of transport and travelers are all part of an integrated MaaS-ecosystem. An interaction between them is necessary in order to enable a truly intermodal mobility solution. Basically, it can be distinguished between Transport Service Provider (TSP), Mobility Service Provider (MSP), Smart Cities and Regions and users of mobility services (MSC). For each role stakeholders are playing, a particular profile with corresponding interests and expectations from other roles can be associated.

Smart Cities and Regions enhance the inhabitants’ quality of life by ensuring access to mobility as well as offering adequate and cost-effective transport services and infrastructure. By being responsible for traffic management, traffic planning and anticipatory transport policy measures, their long-term objective is to foster environmentally friendly mobility to reduce motorized private transport in cities to a minimum. This requires valid insights of citizens’ travel habits, their mobility demand and modal split.

Transport Service Provider provide local transport offerings ranging from bike and car sharing, on demand transport or taxi services and ride sharing. They want to become an integral part of the local urban transport system, in order to gain more visibility in the market and win new customers. To achieve such a target, TSPs need access to detailed statistics from MSPs regarding customer mobility demand.

As a key indicator for smart urban mobility, Mobility Service Providers develop intermodal mobility solutions for Mobility Service Customers (citizens, commuters, travelers). They are responsible for the technical implementation of an intermodal mobility solution – that means: wide range of urban transport services, combined with technical features for routing, booking and paying and a costumers-friendly app design. Their implementation of a MaaS solution would benefit from a centralized access to all modes of transport and an easy contracting process.

Travelers, in this paper so-called Mobility Service Customers (MSC), desire easy access to mobility and seamless travel experience. By understanding mobility as a service, travelers take on a central position. They want to take efficient routes through cities and regions, regardless of time tables and pre-determined means of transport. They want to choose and combine different transport services, and ideally, book and pay for the trip in one tab on their smartphone. In order to integrate a sustainable way of transport in their daily routine, MSPs or cities need to offer incentives to MSCs, e.g. bonus points for CO2 savings, vouchers or loyalty programs.

Following this role model and its characteristics, the fundament for a viable business model of a local mobility marketplace has been developed, focusing on sharing costs between all beneficiaries – including...
both private and public stakeholders. To adapt travelers’ mode choice accordingly, alternatives to deal with people’s mobility demand have to be made available via TSPs and made accessible via MSPs. Starting with a comprehensive analysis of status quo regarding current traffic problems and available respectively missing transportation services locally – e.g. city and its catchment area – a strategic goal and a roadmap is deployed. Based on this, FluidHub as the Platform Service Operator of a MaaS ecosystem is introduced to enable a local mobility marketplace that is capable to fulfill both the expectations of the MSPs (e.g. centralized access for all kinds of mobility, simplified contracting) and TSPs (e.g. increased visibility on the market). It furthermore enables an efficient and transparent management of TSPs and MSPs, which also includes a usage-based accounting to invoice the beneficiaries within tomorrow’s eco-system accordingly.

Like a smart connecting piece, FluidHub links Transport Service Providers, Mobility Service Providers and their mobility customers in one city. Furthermore, technical features offered by enabling service providers, like routing, booking or payment options, are handled in FluidHub directly, before the development process by MSPs can continue. FluidHub is essential to combine a traveler’s individual mobility demand with mobility services, by integrating, editing and connecting the data of all stakeholders within the ecosystem in a cloud.

To optimize the public investment for enabling a sufficient level of mobility for its citizens and even improve the service quality, based on anonymized mobility data generated by the end-user services, an on-going analysis of the mobility behavior takes place and is made accessible via FluidHub. It’s important to mention that diversification of MSP target groups is key. Ideally, local MSPs refer to already established customer relations and big customer bases (e.g. automobile clubs).

Furthermore, it is relevant that the role of a PSO can either be taken by a public entity, a private company or even being contracted via a PPP model. Nevertheless, to foster sustainable modes of transport, when it comes to the definition of the regulatory framework some kind of intervention towards the public interest makes sense.

Thus, it’s all about establishing a viable business area for both MSPs and TSPs to promote easy access to sustainable transport offerings.
CONCLUSION

FluidHub provides Mobility Service Providers with a connection to a wide range of transport service offerings, enabling them to give their customers the best travel experience. The standardized interface offered keeps the integration effort for MSPs low. By partnering with FluidHub, Transport Service Providers reach out to new customers whilst retaining full control of their data and their power over third party service providers. Smart Cities and Regions, that demand regulatory guidance for the MaaS market, receive with FluidHub a framework for urban mobility that takes local interests into account. FluidHub has a scalable and modular architecture making it easy to work with different standards and services. FluidHub as a Platform Service Operator in MaaS technologies may become the missing piece to assist cities and regions in bringing MaaS in the city to alter individuals’ way of travel.
Scalable mobility markets

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Background

In November 2016 Tekes together with FLOU Solutions Ltd. and the University of Tampere initiated a collaborative R&D project to define and develop an open, platform independent API specification for new mobility services. A public-private partnership was formed to conduct the project, named Building an Open Mobility-as-a-Service Ecosystem with a Finnish–Swedish approach (BOMaaS).

Purpose

Despite the approaching EU and national level regulations on digitalization of the information exchange between transport providers, public authorities and other players on the field, the Finnish mobility market is still largely fragmented and cooperation with outside partners is mostly limited.

In this article, Mobility-as-a-Service (MaaS) is used to describe a service concept where the mobility operator is providing complete mobility solutions to the end-users. To fulfill their customers’ travel needs the MaaS operators provide trip planning services that build travel chains utilizing one or more individual transport service provider (TSP). The MaaS operator will also aim to provide seamless user experience to all aspects of travel including routing, booking, guidance and billing.

Although the focus in this article is on the MaaS concept, the findings and the proposed approach are applicable to many other transportation and mobility scenarios as well.

Large marginal cost of entering a new partnership and the associated risk makes the parties careful in partnering. In some cases, the market players might not see the possible increase in user base worth the extra risk. On a sparse and fragmented market MaaS operators are forced to compete on available partnerships instead of being able to focus on providing the best possible service selection and the end-user experience. A prerequisite for a viable ecosystem is the chance for new and existing stakeholders to integrate and communicate effectively. To ensure this the participants are designing an open specification for APIs available for all stakeholders.

Our approach aims to clarify the minimum common requirements, that enable formation of roaming-enabled market places where transportation services can be exchanged. The proposed methods and specifications are designed to be open to all market players and will not be tied to or controlled by any single entity. The purpose of the study was to identify concepts for a dynamic and scalable mobility market and to specify and demonstrate the tangible next step to the MaaS startup phase. The projects focused on market mechanisms, information exchange methods and open APIs.
Methods

The project started with background interviews involving different stakeholders. Agenda and input groups were recognized. Through the interviews and lookouts on other fields sharing similarities with mobility sector, several features of a successful scalable market were recognized. To provide a template solution for information exchange, a reference architecture was drawn. Market mechanisms were modelled to recognize the impacts on different stakeholders and to indicate the comprehensive benefits.

Findings

Single harmonized API specification to all transport services was found to be unfeasible in the short run. Large number of legacy software and backends make adaptation slow. To accommodate the evolution of new APIs and to allow immediate integration of existing services, a proposed **multi-standard architecture** was specified. The architecture is based on service discovery (Service Registry) where metadata of individual services can be published and queried. The published services are divided in categories based on the service type they provide (routing, ticket sale, raw route data, etc.) and the API or format specification how the service is provided (OpenTripPlanned, GTFS, …). This allows the querying client to search a subset of services that they are able to utilize. The service registry can also provide an overview of most common specifications for each service category and help reinforce the formation of de-facto standards. The interest of service providers is to offer the services using the standards that can serve as many clients as possible. Likewise, the client developers can concentrate their resources on implementing the most commonly used standards. The architecture will allow servers and clients to implement multiple parallel APIs for the same service. This will allow an adaptation of new API specifications while keeping up the support for legacy systems.

International collaboration on information exchange methods is the key to find the most suitable de-facto standards and to enable seamless cross-border travel chains.

To accommodate the proposed multi-standard architecture, dedicated Service Registries are needed. The Service Registry work as a search engine for finding various transport related digital services. Each service provider will register their services catalog with a service registry. The catalog specifies the type of service provided, user API specification, endpoint address and geographical area where the service is applicable. The service registry will read the catalog and store it in its database for later reference. When a client (end-user, MaaS operator, etc.) want to discover a new digital transport service it will send a query to one or more service registries and will receive a list of services filling the query criteria. The client can then directly contact the service provider and the service registry play no role in providing the actual services.

To provided extra redundancy and prevent any one instance from controlling the transport market, the service registry infrastructure should be distributed and duplicated by multiple providers. Easy duplication of data can be accomplished by service registry providing a complete list of used service catalogs for other service registries. The maintainer of the service registry can set limits who can register or query services, but the registry can also be open for everyone. The security of the services is not dependent on the service registries. Distributed systems with more than one stakeholder taking care of each role in the reference architecture prevent the market from being stagnated or controlled by a single party.

A large challenge to a scalable transportation market is the mutual trust of all involved parties. Many of the physical transport services are provided by local operators while the MaaS operators can be nationwide
or global. The service registry infrastructure can provide visibility for the local operators, but does not guarantee their trustworthiness. A system where each MaaS operator (or end-user) must individually validate and audit each transport service provider is not scalable.

The proposed solution for a scalable trust mechanism is wide adaptation of Public Key Infrastructure (PKI) and trust chains through shared Trusted Bodies.

The PKI is using asymmetric cryptography to proof identity of all actors in the field. The identity of each actor is based on a pair of encryption keys. One of the keys is freely available for anyone (public key), while the other one must be securely held by the owner of the key (private key). The owner of the private key can proof their identity, digitally sign documents or decrypt messages encrypted with the corresponding public key.

The content or signature of a signed document cannot be modified without access to the private key, but anyone with the public key can validate the authenticity of the document. Digital signatures provide reliable method of relying documents through multiple parties while simultaneously maintaining proof of authenticity. In case of mobility services these documents can include certification, user identification, discount group memberships, user licenses, ticket products, etc.

To tackle the aforementioned challenges of the scalable market and the disparity of the MaaS operators and TSPs business models, it was seen that for the formation of wide area services it’s vital that the inclusion of new TSPs to the MaaS operators service palette must be possible without active one-to-one negotiations and manual integration. Instead of TSP approaching each MaaS operator or wise versa, the proposed solution is to TSPs to publish their service catalog, accepted licensing models and audit status through common APIs. Licensing models and auditing is proven using digitally signed certificates provided by Trusted Third Parties (TTP). MaaS operator can automatically include all registered transport services with compatible licensing models and auditing certificates the MaaS operator requires. TSP whose services MaaS operator wants to use can similarly require MaaS operator to present required certificates to prove their identity and ratification of required agreements.

The chain of trust through TTP reduces the number of negotiations and agreements required for the interoperability of the transport services. e.g. parties to work with each other traditional one-to-one agreements are required (fully connected graph). By introducing a shared trusted third party the number of agreements can be reduced to agreements (one agreement with each of the actor and the TTP). As can be seen when is increasing the traditional one-to-one agreement model quickly increases unfeasibly high and market growth stagnates. In TTP model the number of required agreements grows linearly and each new service provider entering the market is required to make only one contract independent on the number of previous service providers.

In practice, the previous example is probably not feasible. The model requires all the parties to work with each other through single TTP. More likely (and recommended) scenario is a formation of multiple TTP with compatible agreement models. This will lead to multiple parallel and overlapping trust chains where one service provider can belong to one or more of the chains.

The membership of each trust chain is proven by a digital certificate signed by the TTP. By signing the certificate, the TTP ensures the actor receiving the certificate fulfills all the criteria (decided by the TTP) tied to the certificate. The requirements for the certificate are freely definable by the TTP but in most cases,
will include a ratification of some contract. The value of the certificate (and the TTP) is depending on the usability of the contract and the trustworthiness of the TTP.

Implications

Our results imply that more direct collaboration is needed to save resources, to make new services easily pluggable and to demonstrate the benefits of shared de-facto standards. An initiative to form an open developer community for open mobility was set. The main purpose for the community is to focus the limited resources carefully and to start a constant collaboration with other similar communities around the EU as well as the rest of the world. Public sector benefits, the fundamentals of traffic flow theory and the nature of the multi-stakeholder field rationalize orchestration and a partial public funding at the beginning of the collaboration.
MaaS – From Vision to Implementation

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KEYWORDS Integrated Mobility Platform, lessons learned, success factors, business models

With the evolution of the digital revolution, with connectivity having become a defining feature of everyday life, Mobility-as-a-Service (MaaS) has quickly developed from an abstract concept towards an achievable objective with large potential for both the public and the private sectors. We will not dwell on the definition of MaaS, plenty of documentation and is available.

This paper describes the key characteristics and some of the lessons learned while working on three commercial projects for the implementation of integrated intermodal mobility, and it highlights some of the critical factors for the success of MaaS deployments.

Handsfree ticketing on trains towards the Swiss slopes

As part of its objective to offer customer a seamless and comfortable traveling experience, the Swiss rail operator Süd-Ost-Bahn AG (SOB) seized the initiative early on and in 2014 conducted a pilot project to test the feasibility and acceptance of a handsfree Be-in/Be-out (BiBo) ticketing solution. The pilot was so successful that in 2015 SOB awarded Siemens the task to develop and deploy a multimodal sales and information platform for seamless, intermodal trip planning and payment along a chain of multiple modes of travel [1]. In early 2017 BiBo operations, which enable travelers to board a train without the need to previously purchase a ticket, started for a closed group of users; at the end of a trial-phase they will go live for the wide public, with an app and an integrated online shop [2].

Handsfree ticketing offers travelers and operators alike several advantages.

Travelers have no need to stand in line in front of the ticketing machine, no need to study a complex tariff system and wonder whether a day-pass or a return ticket is cheaper.

In many cases handsfree mobile ticketing facilitate the boarding process, thus offering the potential to reduce stop time. A feature which is easy to implement with a post-trip paying mechanism such as the one used by
SOB, is the “best-price” option. With “best-price” travelers are charged only the most convenient tariff for their trips, including e.g. a monthly pass, whenever this is cheaper than the sum of the fares for the single trips performed.

Handsfree ticketing facilitates hopping on and off public transit but the SOB sales platform goes beyond selling transit ticket for the whole of Switzerland. Travelers will be able to use and pay for a wide range of transport and leisure services, including rental cars, Park&Ride and even ski lifts.

Siemens delivers the sales platform based on the “Platform as a Service” model, according to which the system is installed, supported and operated by Siemens for SOB. The upfront investment and the revenues generated by the platform are shared between SOB and Siemens, according to a contract that reduces SOB’s initial investments and splits the financial risks and opportunities between customer and supplier.

A travel companion in Dubai

In 2016, Dubai’s Road and Transport Authority (RTA) set out to deploy an integrated mobility platform whose objectives support Dubai Government’s happiness agenda to “taking a leading role in achieving people happiness, acting in conformity with customers, and boosting happiness & positive work energy” [3]. Recognizing the need to increase the share of public transport use and reduce the motorization level – as well as transport related emission and fatalities – RTA launched a public tender for the deployment of the Dubai Integrated Mobility Platform (DIMP).

DIMP aims to integrates RTA’s own with 3rd-party transport services to provide travelers with a one-stop mobility solution, covering all modes of transport in the Emirate, such as bus, tram, metro, ferries, taxi, limos, car-sharing and ride-hailing. DIMP offers travelers a simplified registration process, an intermodal, door-to-door trip planner for effective and reliable planning and information, and a seamless integrated payment process, unifying access to services provided today by12 apps.

Since the end of 2016, a team of Siemens and its project partners have been working with the customer to deploy the DIMP solution, in a series of delivery milestones with increasing levels of complexity across the number and type of transportation modes and the functionalities offered.
The most obvious component of the solution is the traveler front-end, given by the S’Hail smartphone apps [4], and Web User Interface, while the more complex part of the solution is the backend system. This is responsible for all the functions related to user management (registration, authentication, account management) and to intermodal trip planning and execution, including booking and payment. The backend system is also responsible for managing the various data interfaces and integrating with the subsystems from all service providers.

**Door-to-gate: MaaS at the Munich Airport**

Munich Airport has developed an innovative information service for passengers traveling between city centre and the airport, directly to and from the gate. The solution helps passengers, visitors, and *meters-and-greeters* plan their trip to and from the airport [5].

The Mobility-as-a-Service approach integrates transportation options for trips to and from the airport and includes passenger guidance within the airport with an indication of the expected processing times at the various check points along the trip. The service is expected to significantly reduce the hassle and stress caused to travelers by delays on the way to catching a plane, whether on the road to the airport, at check-in or towards the gate.

In this project the Siemens mobility platform integrates real time information, availability and routing from a variety of local and regional transportation services, such as taxi, city and regional trains, car-sharing, and the Lufthansa Airport Bus. The modular, scalable and multi-client IT platform enables this door-to-gate service to grow, both by connecting additional service providers and by extending the range of functions offered to the user, with options for booking and payment. Also, with a roll-out to other airports in Germany and internationally, the travel experience can truly become end-to-end.

The current project is one of the first initiatives to take a comprehensive look at a passenger’s journey and provide a “one-stop-shop” for travelers with highest possible comfort in the collection of information. The integration of transport services to and from the airport with the service processing within the airport creates a first of its kind solution.

Multimodal solutions require to bring multiple stakeholders to the same table. Enabling the necessary IT infrastructure was essential to get the project going. Systems and platforms needed to provide flexibility in the set-up and high scalability for the extension of the solution. However, in order to enable comprehensive Mobility-as-a-Service, integration has to be handled on multiple levels, relating not just to technology but also to contracts, processes, and business.
Findings and implications

Efficient and effective digitalization requires the right technological solution – and also much more.

The above projects and additional experiences resulting from the interaction with MaaS stakeholders around the world provide indications on some critical success factors.

Get started with a set of agreed use cases, then learn and develop further, and be ready to scale up.

When starting with a MaaS deployment, it is important to have a clear vision of the objectives, but it is not advisable to try and address all possible issues from the very beginning. What’s more important is to allow for a degree of flexibility in the specification of requirements and development of the solution. This requires a continuous and close interaction between the involved actors, with – ideally – no intermediary in between, and thus with dedicated teams, on all sides, for the development and refinement of the solution.

Readiness of participating service providers is key to success

While not all can be in place from the beginning, a high degree of readiness on the part of service providers is needed early on. This requirement relates to both technical readiness, i.e. the availability of IT-systems, of suitable interfaces, API, etc.; and to administrative and legal readiness, i.e., the existence of conditions and contracts for data usage and sharing, and of automated processes for authorizing booking and payments.

Open data and common standards are good but reliable data is critical

The creation of open data protocols and common standards for communication and data modeling will certainly facilitate the further deployment of MaaS solutions. However, a critical factor is the high quality of the data being exchanged and proposed to the user, be it a transit schedule or a booking confirmation for a shared car. Reliable data quality is one of the prerequisites to induce people to leave their cars at home.

Quality of service and end-customer focus are core, from the beginning.

No solution fits all: requirements for functions and services change with the type and availability of transport services and with the characteristics of the user. E.g. if a metro service has a frequency of 3 minutes, the value-added of providing schedule information is close to zero. On the contrary, reliable information on service disruptions or major delays is what travelers will find most valuable. On the contrary, in a rural area where bus services have a frequency of 30 minutes, knowing that a bus is 2 minutes ahead of schedules is a very valuable piece of information.

A commuter will use its travel companion differently from a tourist, but if both are expected users of the service, the app and the underlying backend system must cater to both. Additionally, experience with Dubai and Switzerland shows that users in different countries have different expectations on the look-and-feel, configuration, and use of an app. This led, for instance to the provision of a configuration dashboard within the S’Hail app.

Finally, a high level of service must be properly delivered from the very beginning, even if within a reduced scope. Failing this, by for instance providing a non-reliable trip planner or a non user-friendly interface, it will be impossible, later on, to recapture users who’ve been disappointed with their first impression on the service.
References

BUSINESS 3

Tools for cities and business
MaaS readiness level indicators for local authorities

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The MaaS readiness level indicators give a cross-sectoral view on how prepared each local authority is for the change and what sort of decisions it has already made regarding transportation and how these support the implementation of the new transport services.

The CIVITAS ECCENTRIC partner cities consider the readiness level indicators as a checklist for the local authorities as they make plans towards a more sustainable inclusive transport system. The indicators help to ensure that none of the most critical aspects will be forgotten in the planning process. In many cities the MaaS concept is very new and therefore the level of knowledge varies a lot. These readiness level indicators can also be used to deepen the discussion and shared understanding of MaaS in the local context.

Currently the availability of each transport mode (e.g., carsharing, bikesharing, ridesharing etc) is very low or fragmented. Therefore the MaaS operators have substantial trouble to tailor and supply a good combined service. This MaaS readiness level indicators offer a starting tool to speed up the process among local authorities.

During the development of the MaaS Readiness level indicators it became evident that the legislation in the countries varies a lot and in majority of cases, is delaying the MaaS process. The indicators are limited to the scope on which the local authorities can directly influence, not on other areas of business, such as insurance sector etc, who on their behalf can do a lot to speed up the process.

In many cities, parts of the MaaS puzzle exist already, but not the entire picture. These indicators are only showcasing the readiness level and giving some possible perspectives for the future development that can be taken in local authorities. These can act as a check list that can be used for MaaS development.

The MaaS readiness level indicators for local authorities was published in September 2017 in CIVITAS Forum in Torres Vedras, Portugal. The readiness level indicators will be presented in the 1st International Conference on Mobility as a Service by the author of the publication, Stella Aaltonen.

The publication itself can be found from: http://civitas.eu/sites/default/files/maas_readiness_level_indicators_for_local_authorities_web.pdf
West Midlands MaaS Openness Maturity Assessment

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The TravelSpirit Index of Openness for MaaS is simple and practical tool to help those developing MaaS systems understand their current position and their potential for developing an open MaaS model. This case study applies the tool to the West Midlands model of MaaS being developed between partners and led by Transport for West Midlands. It is an initial assessment for demonstration purposes, which will be further validated and developed by UCL. Further developments will be published in late 2017. TravelSpirit is championing the critical role of “open” in the delivery and development of scalable and sustainable new mobility services. This is necessary for the evolution of Mobility as a Service (MaaS) as a global resource rather than an individualised business.

No written submission.
Open mobility data integration platform: Lowering the threshold for introducing smart mobility services

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Purpose

Utilisation of open resources could accelerate and simplify smart mobility service development and introduction. This paper presents a basic architecture and implementation for an exemplified smart mobility service and how it can be integrated and extended based on the open-source platform such as Digitransit (ref. Digitransit). Digitransit is an open nationwide journey planning platform developed by HSL and Finnish Transport Agency. The Digitransit platform architecture is based on a micro service model. In such a model, small and stand-alone micro services jointly constitute more extensive service bundles and combinations. This kind of architecture enables easy and flexible introduction of new functions and configurations. Open source code enables participation in the platform and service development for anyone interested. The purpose of this paper is to present a concept on how to utilize existing and open resources, such as open data, open or shared API’s and open-source software components for minimizing unnecessary replication of existing functionalities and focusing to truly value adding components.

Methodology

Desk study with concept definition and a proof of concept case study implementation.

The Concept

A smart mobility service can be built on three elements: 1) mobility (real-time) data sources, such as on-board computer or vehicle mobile client, 2) integration platform (provides API solutions for data storage and retrieval), and 3) end-user services (providing application/service specific implementations). Figure 1 outlines the proposed general open mobility data integration platform concept.
The aim of this work is to demonstrate how to utilize existing and open resources, such as Digitransit platform, to avoid unnecessary replication of basic components, to achieve necessary local integration but still heeding to local special features and requirements and lastly to achieve the level of sustainability and scalability. The standards and business models along with legal framework issues, although important for achieving commercially viable solutions, are left outside the scope of this paper. The following section (Case Lapland) presents a basic architecture and implementation for an exemplified smart mobility service tailored for the needs of specific area - a remote tourist attraction in Lapland.

Case Lapland

Case Lapland deals with a number of small separate tourist areas, each having limited development resources set limitations for the realization of functional and commercially viable mobility services for their own areas. On the other hand, there is no central party taking responsibility to manage mobility services for whole Lapland. The nature of the tourist activities in Lapland is highly diverse and greatly changing demand for services (e.g., high and low seasons) sets challenges for viable service solutions. To meet the challenges the mobility solutions must be extremely adaptive to meet highly variable demand and ad hoc needs. Ticketing and payment should be flexible to allow the use of different available mobility solutions and viable business models. The solutions should combine all the available resources, including public transportation, on-demand transportation, shared rides and resources and active transportation modes, such as walking and cycling. The needs of local residents as well as visiting tourists should both be served and all end users must be provided with up-to-date information services with real-time features for effective use of available mobility services. For example, last miles from transport hubs (airports, trainstations, bus stations) to remote destinations should be connected seamlessly to travel chains of tourists and feeder transport services need to have flexibility (in schedules) to respond delays or changes of main transport mode. Feeder transport services serve passengers hopping in along the route and they should be informed on predicted delays and stop times, especially in harsh winter conditions.
Developing a feature rich and good quality mobility services for specific rural areas, such as tourist attractions in Lapland, is challenging task. To achieve any level of sustainability and scalability, it would be practical to seek existing similar solutions that could be either deployed or integrated to existing components. As in many cases the need for the mobility services is not restricted to one specific area only it would also be reasonable to seek integrations spanning adjacent areas to cover wider areas. Figure 2 outlines the proof-of-concept mobility platform implementation based on extending the Digitransit service platform.

The defined mobility service integration platform, comprising open-source Digitransit platform (https://digitransit.fi/) and components that we are proposing to extend its features, provides interfaces for the end-user and vehicle mobile applications, as well as for functionality related to system operation and management such as storing route data and updating map data. With open and well-documented interfaces, mobile application development can be implemented as separate projects, and third party services can also leverage the data and services provided by the mobility service integration platform. The Digitransit platform provides the core functionalities, such as the route planning algorithms, which are based on Open Trip Planner (OTP) (http://www.opentripplanner.org/).

The Digitransit platform offers the following complete sub components:

- GTFS data recording
- Routing interface
- Real-time interfaces (supports real-time vehicle locations, stop forecasting and exception notifications)
- Map and address data. Digitransit uses Open Street Map. Street network, background map and address search POIs (Point of Interest) are automatically downloaded from Open Street Map.

Digitransit as well as GTFS standard on which the data used in Digitransit are, however, not optimal for the requirements for the Case Lapland as it is now. For example, GTFS is created for regular route traffic with stable information whereas in Case Lapland timetables, routes, types of transportation etc. can change with short notice. The timetables may also dependent on the actual real time departures and arrivals of some other vehicle (e.g. a flight arriving to the main transportation hub). GTFS standard also does not support several and flexible pricing schemes for the area. Digitransit, also does not support new novel sharing concepts (e.g., shared taxi rides, shared private cars) which require highly dynamic updates for the available mobility means from great number of possible service providers.
To complement the existing Digitransit platform we propose complementing functionality to cover the special needs of the Case Lapland (briefly exemplified above). The mobility service integration platform for Case Lapland should provide the following interfaces (including third-party applications) for achieving local integration and missing functionalities (see Figure 2):

- Implementing fixed routes (FixedRouteAPI)
- Automatic generation of vehicle routing information based on (long-distance) traffic schedules (GTFSGenerator)
- Manual entering schedules, storing and integrating them as a GTFS packet (RouteAutoCreationAPI)
- How to store and update vehicle routing information in GTFS (GTFSUploadAPI)
- Route planning for on-demand public transport
- Buying a ticket (TicketingAPI)

The end-user mobile application (EndUserMobileClient) provides the traveler a travel planning interface with features like routing and route suggestions, paying a trip on mobile and tracking vehicle location on the map.

The vehicle mobile application (VehicleMobileClient) transfers interactively data such as vehicle’s current location, customer stopping data, notification of exceptions, etc., and is integrated into Digitransit platform real time interface (RealTime API).

Implications

By adopting existing mobility service integration platform, mobility service developers may focus better on user experience and value-adding service components. The micro service model makes it possible to take into account the special characteristics of certain regions as well as increase the number of new functions. The model is also providing the opportunity to develop a database for varying needs, providing a more versatile product range. The use of open source and a broader community of developers can support faster development and inclusion of new features that can be tested by a wider user base.
Implications for city planning
Changes to Travel Demand Modeling in the Age of MaaS – example of Brutus

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1. Purpose

Urbanization is a trend bringing ever more people into cities, pressuring cities and individuals to search for solutions that manage daily travel needs in an effective and environmentally sound manner. One solution is the Mobility as a Service, or MaaS-concept, based on the idea of offering the consumers a wide range of mobility alternatives, motorized and non-motorized, all easily accessible through modern technology. Simultaneously many cities are developing their public transport systems from fixed lines based systems, which in most cities, are at least to some extent inefficient, into systems that are built on fixed trunk lines complemented with efficient demand-responsive services. Digital customer interfaces and optimisation systems make such services easily accessible to customers and also profitable for the cities offering these services.

What’s the traveler potential for the new demand-responsive service I should prepare for as a city officer? What is the optimal public transport service portfolio? These are relevant questions that most of the traditional transport demand forecasting tools cannot answer reliably. There is a clear need to develop new kind of modeling tools that are designed to model confidently the user response for today’s mobility service offerings. In this paper one of such solutions is discussed in more detail.

2. Methodology

Introduction to Brutus

Brutus is a next-generation multimodal transport forecasting model, developed by Stratica Ltd of Finland, that simulates each individual and their daily trips separately, taking into account individual preferences and socio-economical thresholds, instead of operating with mean values of a limited number of demographic subgroups, traveling between large Transportation Analysis Zones (TAZs). Moreover, mobility behavior of the individual is handled realistically as trip chains. Vital inputs include high-granularity land-use data, modal networks and their service levels, and also a regional travel survey including individual trip data. The resulting geographical resolution of Brutus is high, which is important when modeling cyclists, pedestrians and demand-responsive transit (DRT).

In Brutus, the whole regional population is reconstructed by replicating the households and individuals observed in a recent travel survey in a manner defined by certain explanatory variables, until the population forecast is met. The number of person types depends on the volume and statistical quality of survey information. In virtually all cases, the number of person types far exceeds the number used in regional four-step models. Such models tend to be quite coarse, placing people into a limited number of income, age, and car ownership per household bins.
Then, Brutus picks an individual to be simulated and searches from the research data for a corresponding individual, who has similar household size, car ownership and employment/income characteristics. The trip destinations, trip times and all background data for this corresponding individual is extracted. Then a destination choice model is used to find the trip destinations for each trip with each possible travel mode, following a trip chain construction logic. This construction prevents highly unlikely chains, such as abandoning one’s car for the remainder of the day and returning home without it.

The mode choice model is used to find the most beneficial mode for each trip. Finally, the trips are assigned to the respective modal networks. The resolution can be high enough that non-motorized trips can be assigned to, for example, different approaches and paths around a large terminal.

*Brutus* fulfills the basic requirement for modeling demand-responsive transit: handling of individual trips with accurate origins and destinations and an accurate time stamp, to allow assessment of how the trip demand can be served with the vehicle supply. The number of vehicle/modal types will be higher, and each can be characterized in more detail than in a conventional four-step model.

**Brutus public transport optimizer – a tool for the planning phase of new services**

An increasingly common initial situation in cities is that they have an existing public transport network, and they are considering to change some of those services into partially or fully demand-responsive services. Indeed, the best option is often not to introduce a new service on top of the existing ones, making them to compete with each other, but to close down inefficient fixed lines and replace them with demand-responsive services. So, the research question is, which part of the travel demand is best served with which type of service. The traditional modeling tools are not designed to answer such questions, they take the existing routes/lines with their service level and other defining characteristics (capacity, speed, etc.) as given input data only. What is missing is the feedback to revise the characteristic based on the assemblage of individual trips that need to be served. Figure 1 shows how the travel time is handled in four-step models and what happens in the real world.

![Figure 1](public_transport_link_performance_curve.png)

*Figure 1* Public transport link performance curve - actual versus modeled
Hence, a new kind of logic is needed to give this feedback in an iterative design process. In Brutus the approach which is called the “Public Transport Optimizer”. It is designed to analyse the spatiotemporal dimensions of trips and, based on that, differentiate the demand to the parts best served with fixed lines, or alternatively, with demand-responsive services. As input, the optimizer takes the simulated public transport trips as well as the main trunk lines representing major infrastructure investments such as rail rapid transit and tram (aka streetcar) lines, that are not likely to be replaced at all. The key point is, that the optimizer designs its own lines, not paying attention to the existing fixed services (except trunk lines).

In short, the functions of the ‘optimiser’ are presented in the following Figure 2.

In the beginning, the PT demand is assigned to car network (and the trunk lines). Next, a new initial PT line is created, based on the trips using the busiest links in the car network. Then, a buffer is applied to find the trips using that line – those that start or end within the walking distance of the line. This method is repeated for as long as there are enough links in the system that have large enough demand, to create the whole initial PT line network.

In the next phase, the trips are assigned again, but now to the new PT network supplemented with car network. Now, the PT lines can have more realistic link speeds, as well as the car network which represents the demand-responsive service at this stage. Some trips will be assigned differently. Then, each line’s demand is analysed, and when the demand in the ends of each line drops below a certain threshold value (threshold for an efficient fixed line), the lines are cut and ended to such points. So the lines become shorter. Then again, the demand is assigned to the new improved PT network.

As a result of the first iteration with the optimiser, we now know where there seems to be potential for fixed lines and which areas and trips are best served with demand-responsive services (the residue from the initial fixed lines).

But perhaps some more demand could be attracted from other modes? To answer this question, we need to take our new public transport service description to the Brutus simulation model, and re-run the mode choice model in there. In this phase, we will give the demand-responsive service option a service level and price.
assumptions. The altered demand is then assigned again to the system, and necessary changes are made to the lines and their service levels. The iteration can be repeated a few times.

As a result from the subsequent runs of the Brutus simulation model and the optimiser we have now created understanding what are the fixed lines that are needed together with the rail-based trunk lines, and by comparing that new line network to the existing network, we obtain an idea which existing lines should be replaced with demand-responsive services.

The final phase of the analysis would be to extract the demand-responsive trips to a DRT trip assignment and fleet optimization simulator that is designed to route the trips on a vehicle level. This step is useful when highly accurate information is needed of the likely trip travel times as well as understanding of the most optimal DRT operating concept (route deviation, zone, wide ranging shared-ride taxi, etc.). Then simulation is done by a search for the concept that minimizes combined operator and user costs subject to constraints such as the need for occasional timed transfers, available fleet size, and other site specific characteristics. Research is underway to combine Brutus simulation with DRT simulation, but results are still preliminary.

3. Findings

The new tool improves the quality of public transport system planning in the era of MaaS and promotion of non-motorized modes. With the help of the Brutus public transport optimiser a transit organization can evaluate the DRT volumes, evaluate effects on the travelers choices, prepare assessment of public transport system’s service level and well as on the overall transport system level. The tool, if used in parallel with a DRT fleet optimization software, can give very accurate results of the travel times and supply side KPIs and will likely become a standard practice in the near future.

In the later stages of the MaaS era, once MaaS apps are in widespread use, their archived data acts as an ongoing travel survey fed back into the model to improve quality based on actual revealed preferences. One can study willingness-to-pay as both prices of all options and choices made are stored. This facilitates further development of the DRT mode in Brutus as an essential part of the multimodal demand model functionality. Popular trip chains can be identified, in order to offer attractive joint prices. All mobility providers attached to a MaaS app will receive useful planning information.

In the final paper, fresh results from the real-world case-studies will be presented, with illustrations and comparisons to existing services.
Auction-based market model for estimating the willingness to use ridesharing services

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Purpose

Assessment of the potential size of a market is crucial information when deciding on whether to venture forth in investing in or founding a business. Therefore, reliable market data plays an important role in operationalising the Mobility-as-a-Service concept. Estimating the potential of new transportation services is especially challenging as geography, timing of trips, reliability of service and willingness to pay all contribute to the success of the new service. In this business case we develop a quantitative method to evaluate the potential market size for ridesharing. The method can be used with currently available data.

The findings of the study help in evaluating the profitability of an easy-to-use ridesharing platform. The method can be further developed to include variation in willingness to pay. To understand the dynamic effects on trip distribution, the model can be embedded to more complete end-to-end travel demand models.

The model

We develop a microeconomic auction model to describe the incentives of drivers and passengers to form a ridesharing match. With this model, the number of matches during a typical working day is simulated. In the model there are two types of travellers: those travelling by car and those travelling by public transport. Every traveller is a potential passenger and every traveller travelling by car is a potential driver. Travellers announce their willingness to pay for ridesharing to a common marketplace. If some traveller’s willingness to pay is higher than the costs that incur to some driver from picking him up, the system matches these trips. A driver can give a ride to a maximum of one passenger.

For the purposes of the model, the studied area is divided into \( N \) regions. For each region \( i \), we assume that the number of car trips from region \( i \) to region \( j \) is Poisson distributed with the average number of occurrences \( \lambda_{ij} \). Furthermore, the number of public transport trips from region \( i \) to region \( j \) is also Poisson distributed with the average number of occurrences \( \mu_{ij} \).

Travellers seek to minimize their cost function, which is

\[
C(t_{ij,m}, s_{ij}, p) = \beta_t(t_{ij,m} + x) + \beta_c s_{ij} + p
\]

where \( \beta_t \) and \( \beta_c \) are the costs of one hour of time and travelling one kilometre by car respectively, \( t_{ij,m} \) is the time spent travelling from region \( i \) to \( j \) by mode \( m \), \( x \) is the time spent waiting for ridesharing, \( s_{ij} \) is the distance travelled by car from region \( i \) to \( j \) and \( p \) is the payment from the passenger to the driver. The payment is positive for passengers and negative for drivers.

Thus, a traveller seeks to minimize the time and travelling costs of his trip while seeking for compensation for picking up a passenger. We assume that travelling by public transportation has only a time cost. This corresponds to a situation where the traveller already has bought a season ticket for public transportation.

A car traveller travelling from region \( b \) to region \( c \) is willing to be a rideshare passenger if
\[ \beta_t(t_{bc} + x) + p < \beta_t t_{bc} + \beta_c s_{bc} \]
\[ p^* < \beta_c s_{bc} - \beta_t x \]

Here \( p^* \) is the passenger’s willingness to pay for the ridesharing. The passenger has to save enough in travelling costs to offset the increased travelling time from waiting for the ride and the payment for the ride.

With similar reasoning, a traveller travelling by public transport is willing to use ridesharing if
\[ p^* < \beta_t (t_{bc,pt} - t_{bc,car} - \Delta) \]

This means that the price of the ridesharing must be compensated with time travel savings gained from sharing a ride.

On the other hand, a driver travelling from region \( a \) to region \( d \) is willing to take a passenger travelling from region \( b \) to region \( c \) with him if
\[ \beta_t(t_{ab} + t_{bc} + t_{cd}) + \beta_c(s_{ab} + s_{bc} + s_{cd}) + p < \beta_t t_{ad} + \beta_c s_{ad} \]
\[ \beta_t(t_{ab} + t_{bc} + t_{cd} - t_{ad}) + \beta_c(s_{ab} + s_{bc} + s_{cd} - s_{ad}) < -p' \]

Where \( p' \) is the driver’s willingness to sell. A driver is ready to pick up a passenger if the price for the ride is higher than the costs that incur from the detour, compared to the driver driving directly to his destination.

By combining the conditions for driver and passenger we get
\[ \beta_t(t_{ab} + t_{bc} + t_{cd} - t_{ad}) + \beta_c(s_{ab} + s_{bc} + s_{cd} - s_{ad}) < \beta_c s_{bc} - \beta_t x \]

Rearranging the terms leads to
\[ \beta_t(t_{ab} + t_{bc} + t_{cd}) + \beta_c(s_{ab} + s_{bc} + s_{cd}) + \beta_t(t_{bc} + x) < \beta_t t_{ad} + \beta_c s_{ad} + \beta_t t_{bc} + \beta_c s_{bc} \]
\[ C_{driver,shared} + C_{passenger,shared} < C_{driver,alone} + C_{passenger,alone} \]

Where on the left hand side are the costs for driver and passenger when they share a ride and on the right hand side are the costs when they travel individually. Therefore, for a match to occur, the combined cost of driver and passenger must be lower when they share a ride compared to the situation when both take the trip individually.

The model is simulated as follows: first the number of trips made from each region to another by car or public transport is simulated. Then all the travellers declare their willingness to pay for ridesharing for car travellers to examine. After this, each car traveller suggests the smallest price with which they are willing to drive the traveller to their destination. The system begins forming matches from the largest difference in willingness to pay and willingness to sell, continuing until there are no profitable matches left.

**The data**

To realistically assess the market potential with the model, data about the trips made in the market area is needed. The data requirements of the model can be satisfied with national or regional household travel surveys and a study about the value of travel time savings. The model can also be applied to future demand forecasted with traditional four-step-models or with activity-based models. Moreover, in the absence of the data, evaluations of the market size can be done with well justified assumptions about the travel demand in the area.
With extensive travel surveys, one can divide the market area into well-chosen regions and use the travel survey to estimate the average number of trips made from one region to another. Four-step-models by construction have the area divided into different regions, and the model’s forecasted number of trips from one region to another can readily be used as the average number of trips made from one region to another. In the absence of this kind of data, assumptions can be made upon how many trips are made from one region to another. If no trip data is available, one could for example try to assess the amount of trips needed for the ridesharing service to be operable.

The data used in this evaluation is from the traffic forecasting model HELMET, which is the four-step-model for the Greater Helsinki area. For the purposes of the HELMET model, the Greater Helsinki area is divided into 1743 regions. For each region the model estimates the number of trips leaving by car or public transport to all other regions during morning and evening peaks and other hours during the day. In this study, the estimates for the morning peak are used as the average number of trips from one region to another, $\lambda_{ij}$ and $\mu_{ij}$. The ridesharing model also needs the cost coefficients for travel time, travel distance and the waiting time for a ride, which were $8.33\, \text{€}/h$, $0.19\, \text{€}/\text{km}$ and 10 minutes respectively. The value of travel time is from Finnish Transport Agency’s guideline values for value of travel time savings.

The simulation

The simulation of the willingness to use ridesharing services was done by matching trips that leave during a fifteen minutes interval. First, the trips leaving during an interval is simulated and all of the travellers announce their travel plans for other travellers. The auction then finds the most profitable ridesharing matches in terms of difference in traveller’s willingness to pay and extra costs for the driver.

The simulation was done with different participation rates in the ridesharing scheme, the participants being randomly chosen from all travellers. Four fifteen minutes intervals were simulated for each participation rate to gain an estimate for the potential of ridesharing during a typical peak hour when awareness of the service grows.

Findings

We find that the proposed model is applicable to estimating the market potential of ridesharing. The model proposes that when all travellers take part in the ridesharing platform, during a typical morning-peak hour almost 74 000 trips could be shared in the Greater Helsinki and the total amount of welfare to be shared is 259 000 euros. Up to 24 000 car journeys can be avoided.

Figure 1 shows the geographical distribution of these gains. The largest economical gains and decreases in the number of car trips could be derived from commuter towns around Helsinki and areas between Ring I and Ring III. Even though the number of car journeys decreases, the vehicle kilometres travelled increases as much as 490 000 kilometres. Most of the increase in vehicle kilometres travelled comes from picking up and transporting former public transport travellers. The underlying assumption is that the public transport lines continue to operate as before despite decreased ridership. The model proposes that public transport companies could lose as much as 40 % of their customers during the morning-peak due to the ridesharing platform.

As awareness of the ridesharing platform grows, a larger relative amount of travellers in the ridesharing scheme get matched for ridesharing. The increase in the relative amount diminishes as awareness grows, but continues to rise up until every traveller takes part in the ridesharing. Figure 2
shows the matching rate as a function of the participation rate. The matching rate increases from 35% when 1% of the travellers are aware of the ridesharing to 57% when all of the travellers take part in ridesharing.

The model cannot be directly used in estimating the potential of automated vehicles as the supply side of the market works differently compared to the proposed ridesharing model. Nevertheless, the ideas behind the presented method should be applicable for the market. With some assumptions about the level of service and operating costs of the automated vehicles, the profitability of the service could be evaluated.
Conclusions

Our results show that ridesharing can work as a mobility service in the examined region. There are economic benefits to be gained from a working and successful ridesharing platform. Benefits include increase in accessibility and decrease in car-ownership which lead to agglomeration benefits and less emissions from car manufacturing. Ridesharing services may be considered as an alternative for traditional public transport especially in the suburban communities.

Ridesharing can be a significant component of a transport system but overextending participation in ridesharing may also have some negative effects regarding current transport policy goals. Especially the reduction in public transport use, but also the increase in vehicle kilometres travelled are against the current objectives. The problem of mileage travelled is closely related to mispriced externalities: emissions, congestion and use-of-space. Increased emissions rising from the mileage can be mitigated with the deployment of new alternative fuel vehicles. Congestion and use-of-space should be managed with dynamic pricing.

The model can be used to better allocate public transport services and to show where other solutions could better fit the purposes that public transport fulfil currently.
Overview and Background: RMI in Austin, Texas

In 2015, Rocky Mountain Institute (RMI)—a 501(c)3 nonprofit working to transform global energy use to create a clean, prosperous, and secure low-carbon future—launched its Mobility Transformation program in partnership with Austin, Texas to demonstrate a new mobility paradigm of “mobility as a service that is electric and autonomous, in cities designed for it”. RMI selected Austin from a national search as an ideal testbed for the future of mobility because its challenges are emblematic of today’s dominant paradigm of car ownership in many low-density US cities. Eighty percent of Austin residents drive alone as a primary form of transportation, many employers provide free parking, and ridership on the regional bus system has declined by 11% from 2012-2016. With its booming economy and growing population, it’s no surprise that Austin has the 13th worst traffic congestion of US cities.

Austin’s leaders know that novel transportation solutions will be critical for the future prosperity of the region and that pouring more concrete will not—cannot—solve traffic congestion. Austin’s culture of innovation, commitment to sustainability, and interest in market-driven solutions make it an ideal testbed. RMI’s close working relationship with public and private sector partners provides an excellent foundation to test hypotheses about how mobility-as-a-service (MaaS) solutions can be designed, deployed, and adopted at scale. This experimentation adds distinct value because end-user behavior determines whether or not solutions succeed or fail. If a solution is designed and implemented, but underutilized because traveler behavior does not change, it ultimately does not contribute to a reduction in single occupancy vehicle (SOV) vehicle miles traveled (VMT). Pilot projects create the opportunity to iterate, make real-time adjustments based on end-user and stakeholder feedback, and measure the impact of those changes.

Methodology - Market District Pilot: Phase 1

In October 2016, RMI launched its first Austin-based MaaS pilot. The project stakeholders include: two downtown employers (Whole Foods Market and GSD&M), the regional transit authority (Capital Metro), Austin’s transportation management association (Movability Austin), and a microtransit provider (Chariot). Phase 1 ran for five months (October 2016 to February 2017), after which the program was extended through 2017 for Phase 2.
In Phase 1, the Market District Pilot tested several hypotheses:

For SOV commuters living within ½-mile of a transit stop (pilot target market):

- **Hypothesis #1 (Circulator):** First-and-last-mile connection to a transit hub creates enough value for the target market that 10% will change to transit for their commute.

- **Hypothesis #2 (On-Demand):** Subsidized on-demand mobility creates additional value, especially for those in the target market concerned about needing their vehicle in case of unanticipated travel or emergency, that 20% will choose transit for their commute.

- **Hypothesis #3 (End-to-End):** An end-to-end shuttle route creates even more value for the target market than a first- and last-mile (FLM) connection, resulting in greater than 20% adoption rate.

For employers located near one another:

- **Hypothesis #4 (Aggregate Demand):** Aggregating demand among co-located employers increases value proposition and ROI compared to the employers individually pursuing solutions.

- **Hypothesis #5 (Procurement):** A common request for proposals and vendor contract will accelerate procurement for participating employers compared to the employers individually pursuing solutions.

**Hypothesis #1 (Circulator):** A year prior to launch, Movability Austin conducted extensive engagement with downtown Austin employers. The Market District, located a mile west of the major downtown transit stops, is home to five large corporate offices. Traffic congestion is already a significant pain point, and is expected to worsen as Whole Foods Market and other employers continue to expand. RMI partnered with Movability to develop an initial proposal for the five employers to leverage MaaS to improve connectivity with transit. Based on discussions and employee surveys, a first- and last-mile (FLM) circulator was selected as the optimal solution, targeting nearly 850 employees living within ½-mile of a bus or rail stop that would connect to the circulator.

**Hypothesis #2 (On-Demand):** A key ambition for the pilot was to motivate SOV commuters to leave their cars at home and use transit + the FLM circulator. Based on surveys, 25% of employees expressed interest in transit options but were reluctant to leave their cars at home because they worried about unanticipated travel during the day or emergencies. To address this concern, a package of discounted on-demand mobility (rideshare, carshare, bikeshare) was included for just-in-case situations in addition to a circulator connecting them to transit during peak commuting hours.

**Hypothesis #3 (End-to-End Route):** Midway through Phase 1, employers were concerned about low ridership on the FLM circulator and the challenge of persuading SOV commuters to change to multimodal solution. Both employers requested a more direct shuttle route in addition to the circulator and provided employee origin-destination data to RMI to inform the design of an additional end-end route. Based on this feedback, Chariot launched an end-to-end route between Austin’s South Lamar neighborhood and the Market District.

**Hypothesis #4 (Aggregate Demand):** The Market District presented a unique opportunity to demonstrate how multiple corporate offices can aggregate employee demand and procure integrated commuting solutions. In particular, shared investment and aggregated employee demand mitigates risk of low ridership and reduces costs, expanding participation to smaller companies. In theory, when more companies demand integrated commuting solutions, more providers will offer new or additional services, leading to better and cheaper solutions for both private enterprises and the general public.
**Hypothesis #5 (Procurement):** In May 2016, RMI designed and released a request for proposals based on requirements agreed upon by the employers. After a three-week response period, seven shuttle operators and six on-demand providers provided responses. Following review and recommendation by RMI, the employers selected San Francisco-based Chariot to provide the circulator. An on-demand package of Car2Go, Zipcar, B-Cycle (Austin’s bikeshare service), and RideAustin (a local, non-profit ride-hailing service), was designed and implemented as a set of coupon codes. RMI coordinated the negotiation of a common contract and marketing strategy with Chariot. Negotiations proved complex, with sticking points including whether to invoice each company a fixed cost based on company size or a varying cost based on ridership and specific insurance requirements. Unable to come to mutual agreement after two months of negotiations, only two employers (Whole Foods Market and GSD&M) signed the final contract and launched the pilot in October 2016.

**Findings & Lessons Learned**

Phase 1 of the Market District pilot demonstrated the importance of a robust customer qualification process, pre-launch “demand insight,” and persistent communications and marketing in driving ridership. Although the pilot was initially structured as a new approach to bulk contracting between employers and service providers, its ultimate success or failure hinges on changing end-user behavior, most easily measured by MaaS ridership. The value of a standard procurement process and active project management were also highlighted by this experiment.

**Ridership**

Ridership of Chariot’s shuttle service increased steadily throughout Phase 1 of the pilot. Figure 1 displays the total number of rides taken each week during Phase 1. This initial data indicates that the end-to-end shuttle route saw a much faster adoption rate than the circulator. This suggests that **Hypothesis #3 (End-to-End Route)** was supported, however, more data is needed to compare ridership trends long-term.

![Total # of Chariot Rides Taken per Week](image)

**Fig. 1.** Total Chariot rides provided per week during Phase 1 of the pilot.
Preliminary data on the utilization rates of discounted on-demand options suggest that these services were not well-utilized. This outcome would refute Hypothesis #2 (On-Demand), but many factors could have led to this outcome. For example, on-demand mobility options may not have been effectively marketed, or may have created ‘peace of mind’ but ultimately were not needed. RMI will continue to conduct focus groups to better understand which individuals have changed their behavior from SOV driving to other modes, and what factors have contributed to their behavior change.

Phase 1 of the pilot underscored the importance of persistent end-user engagement through communications, events, and word-of-mouth among employees. Neither the mobility providers nor the employers could dedicate resources to promote the pilot and navigating multiple corporate communications channels proved challenging for the pilot partners. Due to low awareness, the initial estimates of a 10% adoption rate in Hypothesis #1 (Circulator) fell short. Overall, 53 employees signed up for the pilot, as shown in Figure 2 (below). Of those, 36 tried a Chariot route, 26 rode once or infrequently, and 10 employees became “regular riders” (using the Chariot shuttles for at least 50% of all possible commutes). This meant a 19% conversion rate to regular ridership but only a 4% adoption rate of the total targeted market.

Return on Investment

Based on these ridership outcomes, the per-employee cost was more than five times more expensive that the monthly cost of parking, a baseline used by participating employers as a comparison point for overall ROI. In line with Hypothesis #4 (Aggregate Demand), aggregating employers did increase utilization and improved ROI. However, these gains were marginal and it is unclear if Hypothesis #5 (Procurement) is actually supported by this pilot, as navigating multiple contracts simultaneously added significant complexity. From a process perspective, a more streamlined approach—establish a core employer first, build ridership and awareness, then recruit additional employers to participate—may ultimately demonstrate a higher ROI.

![Unique Chariot Users and Sign-ups](image)

**Fig. 2.** Employee sign-ups and use of Chariot shuttles during Phase 1 of the pilot.
Implications & Next Steps

Market District Phase 2

Phase 2 of the Market District leverages the experience and relationships from Phase 1. Phase 2 (March 2017- December 2017) will demonstrate a more streamlined approach to contract negotiation and developing a comprehensive mobility suite with one employer (Whole Foods Market) and subsequently designing and implementing a comprehensive communications campaign, including a word-of-mouth ambassador program. Ideally, this approach will (1) reduce complexity, (2) increase ridership, and (3) scale to other employers in the region, (4) resulting in a higher ROI for all parties.

Riverside Corridor

Phase 1 illuminated a significant blind spot in RMI’s pilot design: end-user value creation and engagement. In particular, identifying use cases—who will use the service and how they currently commute—provides significant insight into what is required for individuals to change their behavior. RMI intends to apply this approach in a second series of pilots in Austin, this time focused on the Riverside Corridor. Riverside is characterized by: mixed-use development along its major thoroughfare, Riverside Drive; two residential areas (Montopolis and Oltorf); one campus of Austin Community College; and high-tech manufacturing jobs along its southern perimeter. The neighborhood’s demographics are promising for adoption of MaaS (above average percentage of Millennials; high percentage of commutes to Downtown). The corridor is characterized by rapid gentrification and redevelopment, but is also home to underserved communities (40% poverty rate and 58% Hispanic community) that could benefit from new and/or discounted mobility services. RMI is in the process of identifying use cases specific to this neighborhood and engaging partners to select, design, and implement a pilot project.

Mobility Marketplace

RMI is also developing a mechanism to scale these approaches that could act as a “mobility marketplace” to streamline or automate significant enterprise-scale procurement of mobility solutions. The team is leveraging lean startup methodology to vet this concept, including a thorough customer validation process. Although the design of this marketplace is nascent, RMI envisions a brokerage (service) plus platform (product) that provides a mix of (1) analytical tools to help enterprise clients gain insights, (2) optimize those services for employees, (3) aggregate demand with nearby enterprises, and (4) facilitate transactions with MaaS providers.
An End-User Value Creation Framework

Studies suggest that to adopt a new service over an incumbent, consumers need a 2-4x increase in overall value. In mobility, value comes in many forms, including: cost, travel time and reliability, convenience and flexibility, simplicity, privacy, and comfort. Figure 3 illustrates how user value could be quantified into these categories and assessed for new solutions.

For example, comparing a baseline SOV commute with a FLM connection to a rail stop, it’s not apparent that a circulator shuttle creates any value for SOV commuters. Why would end-user behavior change? By contrast, an end-to-end shuttle route may create some value compared to the SOV commute, which would be consistent with the faster adoption rate seen in the pilot. In particular, although many commuters say they don’t use transit because stops are too far from their origin/destination, the data suggest they are not demanding a transfer to a FLM connection, but rather a door-to-door solution that creates value relative to driving. In either case, the remaining “value gap” needs to be overcome through some combination of incentives and penalties.

RMI’s approach to designing commuting solutions has evolved significantly as a result of the Market District pilot. As outlined above, RMI will pursue new pilots and scaling opportunities with a renewed emphasis on user value creation balanced against the importance of whole-system efficiency.

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Figure 3. Illustrating user value creation of a new solution compared to a baseline.

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Extending the MaaS concept
Experiencing Finnair’s new A350 - How service innovation can lead to a price premium

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Abstract

This study focuses on the customer experiences of air passengers travelling on the latest-technology aircraft currently available on the market, the Airbus A350. A questionnaire was conducted in cooperation with Europe’s first A350 operator, Finnair, to study the customer experience of flying on this new aircraft. Altogether 1,404 responses were recorded. The questionnaire focused on the A350 as a service innovation as well as on 10 aspects that had been used by Finnair to communicate the enhanced customer experience of flying on this new aircraft. These innovations were: larger windows, better cabin air, new interior design, 20% increased fuel efficiency, lower cabin pressure, less noise in the cabin, ambient mood lighting, improved food services, better seats as well as improved entertainment systems. In addition to that we also used contingent valuation to test customer's willingness to pay a premium for flying on the A350. Our results showed that there is a significant amount of passengers that showed a willingness to pay a premium for flying on the A350 again. Further, we also detected that certain service innovations had enhanced the willingness to pay such as the improved entertainment system, better seats and less noise in the cabin. In addition to that, we also detected that the 20% increased fuel efficiency had played a significant role for the willingness to pay and that introducing such a new aircraft type can also have a positive effect on the brand image of an airline.

Introduction

Since the deregulation of the airline industry and the market entry of low cost carriers, competition has increased significantly (Baumeister, 2010). While the consumers have been enjoying lower air fares, this certainly has put pressure on the established carriers. Ever since have they been searching for new ways to justify their premium prices through their extended service offerings. One way to make the offering more appealing to the consumer is service innovation. As Victorino, Verma, Plaschka and Dev (2005) found, service innovation can justify a price premium. Nevertheless, so far the idea of using service innovation as a justification for charging a premium price has not received much attention in the airline industry. Therefore, this study set out to investigate whether service innovation can lead to a price premium among air passengers. For this purpose we conducted an online questionnaire among actual air passengers that have recently flown on Finnair’s new Airbus A350. The A350 was introduced in mid-2015 and is currently regarded as the technologically most advanced and sophisticated aircraft in the market. It features vast amounts of technological innovations that have increased efficiency, reliability, safety and passenger comfort compared to previous aircraft generations. Finnair was the first airline in Europe, and the third worldwide, to introduce the Airbus A350 in late 2015.
Methods

In order to study whether service innovation can lead to a premium price in the airline industry we conducted an online questionnaire among actual air passengers that have recently flown on Finnair’s new Airbus A350. The questionnaire was sent to 5,000 Finnair customers of whom we received 1,404 responses. For studying air passenger’s willingness to pay we used contingent valuation letting passengers assume that they have to fly again on the same route with Finnair’s A350 as during their previous flight. For this purpose we showed them four different ticket prices for a round trip in economy class, depending on their route. Two prices were below the average price, common on that route, and two prices above. As the prices were based on economy class round fares we only analyzed the answers of those passengers who had flown in economy class during their previous A350 flight. Those were in total 740 participants. In order to further study which of the service innovations of Finnair’s new Airbus A350 are most appealing to air passengers, we asked the participants to rate those based on their past experience using 7-point Likert scales. We focused hereby on those 10 service innovations that had been used by Finnair to communicate the enhanced customer experience of flying on this new plane. These were: larger windows letting in more natural light, better cabin air through enhanced filtering system, new interior design, 20% increased fuel efficiency compared to the previous aircraft generation, lower cabin pressure, less noise in the cabin due to quieter engines, ambient mood lighting to simulate day and night, improved food services, better and more comfortable seats as well as improved entertainment through WIFI and larger personal screens. In addition, participants were also asked several questions about the overall satisfaction of flying with Finnair’s A350 and what are their preferences when booking a flight using 7-point Likert scales. Finally, participants were asked to rate Finnair and 10 of its closest competitors regarding how environmentally friendly they regard those airlines using a 5-point Likert scale.

Results

The findings of the contingent valuation revealed that 22.48% of the participants showed a willingness to pay an above average price to fly on Finnair’s new Airbus A350, would they have to travel on the same route again. The remaining passengers were not willing to pay the average price and preferred rather lower ticket prices in order to fly again on the same route with the Finnair’s A350. Next we compared the stated satisfaction of both passenger groups with their recent Finnair A350 flight. A clear difference could be detected as those passengers who showed a willingness to pay more showed also a higher rate of satisfaction with 6.03 on the Likert scale while the remaining passengers scored only 5.55. Followed by that, we had a look at those 10 service innovations that were communicated by Finnair concerning the Airbus A350. Table 1 gives an overview of the ranking of those 10 service innovations both from the passengers that showed a willingness to pay a premium and the remaining ones. For the passengers that showed a willingness to pay a premium price, improved entertainment through WIFI and larger personal screens followed by better and more comfortable seats and less noise in the cabin due to quieter engines were the most important service innovations of Finnair’s new A350. Ambient mood lighting to simulate day and night and larger windows letting in more natural light were the least significant improvements. For the remaining passengers better and more comfortable seats were the most important innovation followed by less noise in the cabin and improved entertainment through WIFI and larger personal screens were only ranked third. Also among those passengers the mood lighting and the larger windows were ranked the least important. While the ranking of the service innovations differed slightly between the two groups, the mean values between the two groups were close to identical. The largest difference in mean values could be detected regarding the
20% increased fuel efficiency compared to the previous aircraft generation. Here the passengers who showed a willingness to pay a premium saw far more importance in the fact that the Airbus A350 is 20% more fuel efficient than its predecessor, the Airbus A340.

Table 1. Ranking of Finnair’s A350 10 service innovations by passengers

<table>
<thead>
<tr>
<th>Rank</th>
<th>Product innovation</th>
<th>Passengers willing to pay a premium</th>
<th>Mean</th>
<th>Passengers NOT willing to pay a premium</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>WiFi &amp; larger PTV</td>
<td>6.18</td>
<td></td>
<td>Better seats</td>
<td>6.12</td>
</tr>
<tr>
<td>2</td>
<td>Better seats</td>
<td>6.15</td>
<td></td>
<td>Less noise</td>
<td>5.99</td>
</tr>
<tr>
<td>3</td>
<td>Less noise</td>
<td>6.06</td>
<td></td>
<td>WiFi &amp; larger PTV</td>
<td>5.97</td>
</tr>
<tr>
<td>4</td>
<td>Better cabin air</td>
<td>5.79</td>
<td></td>
<td>Better cabin air</td>
<td>5.77</td>
</tr>
<tr>
<td>5</td>
<td>20% fuel efficient</td>
<td>5.60</td>
<td></td>
<td>Improved food</td>
<td>5.38</td>
</tr>
<tr>
<td>6</td>
<td>Improved food</td>
<td>5.42</td>
<td></td>
<td>20% fuel efficient</td>
<td>5.31</td>
</tr>
<tr>
<td>7</td>
<td>New interior design</td>
<td>5.18</td>
<td></td>
<td>Lower cabin pressure</td>
<td>5.14</td>
</tr>
<tr>
<td>8</td>
<td>Lower cabin pressure</td>
<td>5.02</td>
<td></td>
<td>New interior design</td>
<td>4.91</td>
</tr>
<tr>
<td>9</td>
<td>Mood lighting</td>
<td>4.80</td>
<td></td>
<td>Mood lighting</td>
<td>4.67</td>
</tr>
<tr>
<td>10</td>
<td>Larger windows</td>
<td>3.67</td>
<td></td>
<td>Larger windows</td>
<td>3.60</td>
</tr>
</tbody>
</table>

As the largest difference between the two passenger groups is related to the service innovation of increased fuel-efficiency, we further analyzed the attitudes of both groups regarding the environmental aspect of flying, in order to find out whether there are relevant differences that could play a role in the willingness to pay a premium price for flying on a more fuel efficient plane. This service innovation is also in this regarding interesting to study as it is the only one out of the list of 10 which cannot directly be felt by the passenger or enhance their comfort. Therefore, we asked both passenger groups how important particular aspects to them are that relate to the environment when booking a flight as displayed in table 2.

Table 2. Passenger’s attitudes towards environmental aspects of flying

<table>
<thead>
<tr>
<th>Statement: I prefer to fly with airlines that …</th>
<th>WTP</th>
<th>Non-WTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>… use modern aircraft.</td>
<td>5.93</td>
<td>5.60</td>
</tr>
<tr>
<td>… have a positive attitude towards the environment.</td>
<td>5.23</td>
<td>4.93</td>
</tr>
<tr>
<td>… offer carbon offsetting.</td>
<td>3.73</td>
<td>3.29</td>
</tr>
<tr>
<td>… are testing biofuels.</td>
<td>4.26</td>
<td>3.85</td>
</tr>
</tbody>
</table>

The results in table 2 clearly indicated that those passengers who had shown a willingness to pay a premium for flying again on Finnair’s Airbus A350 saw also much more importance in environmental aspects of flying. Finally, we asked the participants to rank Finnair and 10 of its closest competitors in regard to how environmentally friendly they perceived those carriers as shown in table 3.
Table 3. Ranking of airlines perceived environmental friendliness

<table>
<thead>
<tr>
<th>Rank</th>
<th>Passengers willing to pay a premium</th>
<th>Mean</th>
<th>Passengers NOT willing to pay a premium</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Finnair</td>
<td>4.76</td>
<td>Emirates</td>
<td>4.88</td>
</tr>
<tr>
<td>2</td>
<td>Lufthansa</td>
<td>4.75</td>
<td>Qatar</td>
<td>4.83</td>
</tr>
<tr>
<td>3</td>
<td>Emirates</td>
<td>4.70</td>
<td>Finnair</td>
<td>4.74</td>
</tr>
<tr>
<td>4</td>
<td>Qatar</td>
<td>4.66</td>
<td>Lufthansa</td>
<td>4.73</td>
</tr>
<tr>
<td>5</td>
<td>British Airways</td>
<td>4.57</td>
<td>SAS</td>
<td>4.70</td>
</tr>
<tr>
<td>6</td>
<td>SAS</td>
<td>4.57</td>
<td>Air France-KLM</td>
<td>4.60</td>
</tr>
<tr>
<td>7</td>
<td>Norwegian</td>
<td>4.54</td>
<td>British Airways</td>
<td>4.59</td>
</tr>
<tr>
<td>8</td>
<td>Air France-KLM</td>
<td>4.38</td>
<td>Norwegian</td>
<td>4.55</td>
</tr>
<tr>
<td>9</td>
<td>Air China</td>
<td>4.12</td>
<td>Air China</td>
<td>4.28</td>
</tr>
<tr>
<td>10</td>
<td>Turkish</td>
<td>4.12</td>
<td>Turkish</td>
<td>4.25</td>
</tr>
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<td>11</td>
<td>Aeroflot</td>
<td>3.55</td>
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Table 3 indicates that those passengers who showed a willingness to pay a premium for flying on Finnair’s A350 also ranked Finnair as the most environmentally friendly airline while Finnair didn’t receive top scores from the remaining passengers.

Discussion & Conclusion

This study set out to investigate whether service innovation in the airline industry could lead to a premium price. The findings clearly indicated that there is a significant share of actual air passengers who are willing to pay a premium for flying again on a next generation aircraft whose service innovations they have already experienced before. While the innovations concerning the increased passenger comfort (improved entertainment, seats, less cabin noise) have been ranked the highest also the improved fuel efficiency has played an important role, especially for those passengers that have shown a willingness to pay a premium. The results have also further revealed that those passengers are paying more attention to environmental aspects when selecting an airline or flight. Finally results also showed that these passengers had ranked Finnair on top among its closest competitors in terms of environmental friendliness. It can therefore be concluded that service innovations in the airline industry through new aircrafts not only stimulate a willingness to pay a premium among a significant group of air passengers but, that the improved fuel efficiency not only means a saving potential for airlines but does also influence the brand image positively.

References


Circular Economy in Mobility: Sharing and Rural Areas

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ABSTRACT

The transport sector accounts for roughly a quarter of all greenhouse emissions. While significant improvements have been reached in improving energy efficiency and environmental friendliness of vehicles and technologies, the challenges for reaching national and international objectives are great. The transport system as a whole is facing significant changes driven by trends such as servitization, increasing intelligence and automation in vehicles as well as infrastructure, and systems that communicate and integrate well with one another. Circular economy is a concept addressing the efficient use of resources at all stages of the lifecycle of a product. In the transport sector technological advancements in vehicles, efficiency improving design choices and low-emission energy choices are leading the way but to complement these, digital services also play a role. New types of digital services and business models are being introduced at a rapid rate. While introducing new opportunities for addressing mobility needs, they lead to new expectations and have their own requirements regarding the need for and availability of resources. This paper investigates the challenges and opportunities related to shared mobility services in the context of rural areas. When it comes to transportation and areas with sparse population and long distances, the sharing solutions showing the highest potential are (1) on-demand transport services, (2) shared taxis, (3) combined transport services for statutory social services, and (4) shared cars.

INTRODUCTION

The transport sector accounts for roughly a quarter of all greenhouse and CO\textsubscript{2} emissions in the EU with road transportation’s share being 72.9% (European Commission 2017). While significant improvements have been reached in improving energy efficiency and environmental friendliness of vehicles and technologies, the challenges for reaching national and international objectives are great. The transport system as a whole is facing significant changes driven by trends such as servitization, increasing intelligence and automation in vehicles as well as infrastructure, and systems that communicate and integrate well with one another.

New types of digital services and business models that are addressing the clear need and leveraging new technologies are being introduced at a rapid rate. They lead to new expectations and situations regarding the need for and availability of resources. This is a well-established matter that is being addressed at different levels. The Finnish government, for example, has circular economy as one of its key projects related to bioeconomy and clean solutions (Finnish Prime Minister’s Office 2016).

The drive for a more resource efficient circular model is pushing companies towards new business models and seeking out disruptive technologies that are based on longevity combined with efficiency throughout the lifecycle of solutions (Esposito, Tse & Soufani 2015). Positioning sustainability as an integral part of a company’s value proposition can help move from a single to a continuous business case creation with cost and market risk reductions or increases in brand value and attractiveness or innovation capabilities as the benefits (Schaltegger, Lüdeke-Freund & Hansen 2012). Rethinking a business case and the value creation can bring about new ways of cutting costs or adding value. Instead of typical linear value chains (Porter 1985), Aminoff et al. (2017) propose that it would be beneficial to differentiate from this by instead considering...
value circles which can highlight the co-existence of several other overlapping value circles, and being more in line with the basic principles of sustainability.

In general, the definitions and relationships of terms such as circular economy and sustainability are often ambiguous and therefore can be inefficient in research and practice (Geissdoerfer et al. 2017). While the “traditional” generalization of circular economy referring to efficient material and waste management (e.g. using and reusing as much components as possible), the concept covers a whole range of solutions and viewpoints. The fact that circular economy is estimated to have the potential to yield €1.8 trillion worth of annual benefits to the European economy by 2030 (Ellen MacArthur Foundation, SUN & McKinsey 2017), it is worth considering more thoroughly what does circular economy comprise when it comes to transport and mobility.

This paper first provides a brief overview of various meanings and possibilities circular economy has in the transport sector ranging from using waste for biofuels and electric vehicle battery reuse and second use to opting to use public transport or sharing rides. We explain different complementary aspects of circular economy through examples. Then, the aspect of digital solutions and specifically sharing economy is further delved into and analysed in the challenging context of rural areas.

METHODOLOGY

This study is based on a literature review on the concepts and implications of circular and sharing economies in the context of transportation that is then further focused into a rural context with analysed case studies. Data on case studies was mainly collected through semi-structured phone and face-to-face interviews conducted as part of the rural-MaaS project as well as user surveys and from a mobility service provider as part of an impact study of the Ylläs Around service.

Rural-MaaS (2016-2017) was a yearlong national project financed by Ministry of Agriculture and Forestry (rural-MaaS, 2017). The project aimed at creating a national vision for MaaS in rural and sparsely populated areas focusing mainly on recognizing emerging and potential business models for both commercial and publicly funded transport services. The project also improved the awareness of MaaS concept and raised the discussion about the mobility services and resource efficiency in rural and sparsely populated areas.

Thirty interviews were conducted in Finland during the spring of 2016 (Eckhardt et al., 2017). Since informal discussion and flexibility were considered crucial for this study in order to identify expectations and ideas for yet non-existing services, the interview questions were relatively broad and loosely defined. The interviews focused on having a robust view of both current and expected potential service combinations as well as the effect of solutions based on circular and sharing economy in different regional areas. Because the development of mobility in general touches various societal levels and various stakeholders, the interviews were carried out both with public organizations (e.g., public and road authorities) and private organizations (e.g., service and product providers) to identify roles and aspects of different stakeholders. In addition to the listed interviews, multiple informal discussions have taken place randomly with relevant people dealing with regional and rural mobility.

Another data set used in this study was collected through two questionnaires regarding Ylläs Around Mobility as a Service experiment. It was an R&D pilot conducted in the winter season 2016-2017. The pilot was jointly financed by commercial transport operators and authorities, and the pilot pursued to study and experiment with a new environmentally friendly, cost-efficient and safe mobility service customised for the
needs of travellers in the Ylläs area, Northern Finland. Two questionnaires were circulated for the impact study, one among service users (N=20) and one among transport operators (N=4). These questionnaires probed users’ and operators’ experiences of the service and the application and requested suggestions for future development. The researchers also had access to user data from the Ylläs Around service. (Finnish Transport Agency, 2017.)

Circular Economy in the Transport Sector

Circular Economy and Resource Efficiency in General

The Ellen MacArthur Foundation (2017) describes circular economy as follows: “Looking beyond the current ‘take, make and dispose extractive industrial model, the circular economy is restorative and regenerative by design. Relying on system-wide innovation, it aims to redefine products and services to design waste out, while minimizing negative impacts. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural and social capital.”

Resource efficiency, therefore, combines using limited natural resources in a sustainable manner and maximizing the exploited utility of the assets. It expands the common narrow interpretation of circular economy view of, for example, focusing on reusing waste and materials and repairing parts to sharing and collaborative economies that have been significantly enhanced by advancements in digital technologies. As a result, not only is a minimal amount of materials used for assets and wasted but also the efficiency in use improves throughout the lifecycle of the resources.

When it comes to transport and mobility, the European strategy for low-emission mobility (European Commission 2016) that supports the shift towards low-carbon circular economy has three main aspects: (1) increasing the efficiency of the transport system (e.g. digital solutions for smart pricing and encouraging sustainable choices), (2) speeding up the deployment of low-emission alternative energy for transport (e.g. biofuels, hydrogen, and electricity), and (3) moving towards zero-emission vehicles (e.g. hybrid and full electric cars).

In the vision report Growth Within by Ellen MacArthur, SUN & McKinsey (2015), there are five levers identified through which mobility could be transformed to a create “an automated, multi-modal, on-demand mobility system” meeting the circular economy vision. (1) **Sharing**: Ride sharing, car sharing, peer-to-peer (P2P) car sharing, app-enabled car-pooling, shuttle buses. (2) **Electrification**: Thanks to lower maintenance and total lifetime costs, electric vehicles are likely to dominate the high-utilisation world of shared mobility, leading to significant environmental benefits. (3) **Autonomous driving**: Autonomous vehicles could improve the mobility system efficiency (e.g. optimal acceleration and braking and reducing congestion by closing space between vehicles, and improving energy efficiency) with sufficient penetration. (4) **Materials evolution**: Lightweight vehicles with better aerodynamics and much longer life; more durable and easy recyclable materials to get a longer life for vehicles. (5) **System-level integration of transport modes**: Shifting between personal, shared, and public transportation in an optimized mobility system and making personal cars irrelevant, and solutions such as congestion charging, bike-sharing schemes and car clubs, smart traffic management systems.

While transport and mobility is a sector on its own in which circular economy has various forms, it is also a part of the lifecycle in other sectors. Particularly logistics solutions play a part in the environmental
lifecycle footprint in other fields, such as route optimization as part of forest-based circulation and combined deliveries as part of food product life cycles and the material and product deliveries and transportation in general. (Sitra 2016)

Considering the potential ways of circular economy described above comprise essentially any and all developments and changes pertaining to transport technologies, services or user behaviour that are not specifically negative towards sustainability, we reckon a more practical categorisation would be appropriate in order to distinguish what solutions may be overlapping or alternative ones and which ones are very indirectly related. In the following sections we will provide examples of how different aspects of circular economy apply to the field of transportation and mobility with this in mind.

We categorise the examples in the following groups (Figure 1) in order to better distinguish how and where new technologies, developments and innovations come into play: (1) design innovations, (2) efficient reuse, and (3) digital services. The categorization differentiates circular economy solution types to provide a broad understanding of how different solutions can be seen as either alternatives or competitors to one another (i.e. within the same category), or as complementary ones that may or may not be linked to the other choices (i.e. across categories). That is, in order to achieve the full benefits of circular economy, improvements should be made in all the categories and within each category the most suitable choices (for a given context) should be found. For example, a vehicle could be designed (category 1) aerodynamically, using resource-efficient and modular parts and processes, while in its use (category 2) it could run on renewable energy, exchange owners and be repaired or used for materials, while digital services (category 3) enable optimization of user behaviour such as optimal driving or access to available services that improve the usage. Essentially, disconnecting the choices made in the vehicle and individual services from the “Mobility as a Service” concept; providing digital services for accessing and connecting users to whatever individual transport options there are available.

**Figure 1.** Complementary (vertical) and alternative (horizontal) solutions. Grey indicating no dependencies or choices (free to improve all aspects); other colors indicating (“competing”) alternatives and resulting dependencies/limitations.
Design innovations - how products are made

The design innovation category refers to choices made at the very beginning that affect the efficiency of a product or solution throughout its lifecycle either as an inherent factor or by limiting further choices. The design, development and manufacturing of transport vehicles (and related systems) is a complex set of processes and tools that contribute to competitiveness and circular economy (European Commission 2017b). Examples of inherent factors would be the weight and shape of a vehicle. A more aerodynamic shape and a lighter weight can, throughout its lifetime, constantly affect the fuel or energy consumption of the car. Another similar design choice would be between engines suitable (or desired) for in small, sub-urban or sports vehicles.

A clear example of a choice that affects future options is the power source. A decision between an electric battery and a combustion engine rules out some improvement and development opportunities such as renewable energy during use and disposal, as further discussed in the efficient reuse section. As the emissions from the production of an electric vehicle battery scale with its weight and capacity (Romare & Dahllöf 2017), the relevance of design choices and intended purpose increases. It also implies that the relative value of other means of improving resource efficiency, such as shared vehicles and rides, may increase in rural areas with sparse population and long distances as range requirements tend to be higher than in urban areas. In other words, environmental savings of electric cars are greater when they are designed for shorter distances (urban areas) whereas sharing a ride removes a need for similar share of resources (i.e. vehicles or driving) in both urban and rural areas. The challenges of remote areas are further discussed later in the paper.

The design of products can also support circular economy by ensuring minimal waste in the production process - or in availability and compatibility in repairs later on - when the parts are designed so that they can be used in several products (e.g. different versions or models). Modularity can reduce downtimes required for changes in, or simply the number of, assembly lines and thereby improve efficiency.

Efficient reuse - making the most of materials and products

One of the obvious ways of minimising waste is to find new uses for and recycling parts, waste and by-products of different products and processes. Biofuels from renewable sources and waste materials are a significant tool in tackling the environmental goals of emission reductions in land, air and marine transportation. It is a particularly relevant aspect from a Finnish perspective, considering 22% of all Finnish exports are connected to bioeconomy (Luke 2016). Another example of using by-products and waste from industrial processes, such as ash and steel slag, in in road and pavement constructions (e.g. Bharath & Narendra 2016).

In general, the various ways of recycling, reuse, redistribution, refurbishing and remanufacturing of products and their materials and components apply throughout their lifetime from buying used vehicles to extracting and reusing precious metals from, for example, electronics.

One of the main trends and ways of reducing especially local emissions in transportation is electrification. While the design choice of going for electric cars or not is obviously relevant for circular economy, so is the latter end of their lifecycle. As the battery of an electric vehicle reaches the end of its life, it is possible to reuse it in different second life applications in order to minimize waste and optimize the use of resources, although it has diverse challenges to solve for efficiently be applied in different possibilities (Kampker et al. 2016; Casals & García 2016). Standardization to support interoperability can enhance the efficiency of the
after-first-life use (Laraqui 2016) but may also need not only a technology push but also policies that further the end-of-life management strategies (Richa 2016).

Digital services - supporting sustainable user behaviour

The role of digital services is finding optimal ways to do things and providing ways to encourage or help people act accordingly. In most simple terms, digital services can aggregate and analyse information to provide more and better information in order for users to make sustainable decisions. And, importantly, making taking the sustainable choice more appealing. For example providing easy channels to access and obtain multimodal itineraries and tickets. Same as for people, in logistics intelligent sorting, scheduling and routing can optimize deliveries to save time, fuel or both. UPS, for example, have reduced their carbon footprint while improving efficiency by heavily favouring right-turns in the delivery routes even at the cost of driving distance in order to reduce stopping at intersections (Business Insider 2011). Further efficiency gains can be achieved, particularly when it comes to long distances and small amounts of packages, when transportation of people and goods can be combined (e.g. by utilising taxis to deliver small items in remote locations) (Joers et al., 2016). In addition to combining goods deliveries alongside traditional transport services, crowdsourced solutions (ad-hoc peer-to-peer services) exist as well, although experiences on their feasibility and user acceptance are so far limited (Punel & Stathopoulos 2017).

Sharing and (re)distribution of resources itself (i.e. having resources to share) is a matter of efficient (re)use but digital services are what make them accessible. Over the past years, sharing economy and digital platforms that facilitate it have created massive amounts of services related to mobility such as carpooling (e.g. BlaBlaCar), ride-hailing (e.g. Uber, Lyft, Didi, Grab, Ola), car-sharing (e.g. Zipcar, DriveNow, City Car Clubs), peer-to-peer car sharing (e.g. FlightCar, Turo), bike-sharing (e.g. Wheelz), accommodations (e.g. AirBnB) and deliveries (e.g. Deliveroo). It is a topic which combines finding efficient solutions (e.g. dynamic routing), changing user behaviour and new cost-revenue models. Therefore, it is at the heart of the circular economy idea of maximising the use of otherwise unused resources. However, it poses a significantly different challenge compared to typical transport services as it is based around the users, assets and their dynamic behaviour. The users act as customers, service providers, asset providers or any mix of the above, making the supply-demand balance sensitive. Since shared mobility is rapidly growing (e.g. Morgan Stanley 2016; Shaheen & Cohen 2016; Goldman Sachs 2017; McKinsey & Company 2017; Marketsandmarkets 2017), it combines the different aspects related to benefits through digital solutions, and its realization in different contexts has varying requirements and expected impacts, we will next focus on this specific aspect.

SHARING ECONOMY

Sharing - or collaborative - economy is essentially built around unlocking the value of resources or assets that are being unused or underutilized, for example, renting out your apartment (AirBnB), vehicle (ShareitBlox Car) or parking spot (Rent-a-Park) while travelling. The definition the European Commission (2016b) has developed for collaborative economy identifies three types of actors: (1) service providers who share assets, (2) users, and (3) intermediaries that connect the providers and users (via online platforms).

Sharing within communities has been around throughout history. Before cars and communication technologies, ride sharing was in place when a neighbour would offer a horse ride to a shop or a church. It tends to be more common and likely within family and close friends than strangers since trust (whether it is for personal safety or security of the value of shared property) is a key issue (Belk 2014).
Developments in information and communication technologies and near ubiquitous smart phones and mobile have enabled online platforms to connect peers as service providers and consumers. Since sharing relies heavily on trust, new solutions such as blockchain that are built around the concept of bringing trust to a trustless transaction while also supporting security and privacy can further improve the efficiency of realizing sharing solutions without middlemen and with more detailed micro-payments for different services. (Sun, Yan & Zhang 2016) It could also improve the current issues of, for example, ride-hailing services where the platform providers’ cut of the fees are further reducing the revenues drivers can earn which can almost be more akin to quick loans than a steady income that would also provide security in terms of health care and retirement (Malhotra & van Alstyne 2014).

The Challenges of the Rural Context

A distinctive issue in scaling transport services efficiently is the fact that it is reliant on physical assets (i.e. vehicles and infrastructure). New digital services providing new channels for discovery and access of mobility services have nothing to offer if the underlying transport option or service is not available. The necessity of having private vehicles in more rural areas, naturally, plays a key role in defining the setting and limitations for introducing alternatives for it. Sparse structure also means costs and utilisation rates of any services (e.g. transport fleets of infrastructure) are relatively higher.

Sharing has created opportunities in improving asset utilization and reducing transaction costs and waste especially in cities (Tedjasaputra & Sari 2016). Indeed, cities are often considered the most important areas for transforming towards more circular economy, notably due to the impact sharing economy can have on user choices regarding ownership and consumption (Cohen & Muñoz 2016). On the other hand, however, collaborative economy which has fuelled disruptive innovations is also considered one of the most significant driving forces shaping the future tourism (Dredge & Gyimóthy 2017) which can be a key factor in remote locations. Combinations and sharing have different requirements but can potentially have even greater benefits for the users at rural areas (e.g. two users sharing the cost of a taxi ride for 100km compared to 10km and simultaneously not taking up two rides when the supply is scarce as it is).

Tourism is an important customer segment for mobility in areas such as Lapland. By its nature, the demand varies greatly from time to time and especially international tourists typically do not have a car available. The needs vary as well even within a region depending on local sites. A family with children will have different requirements and opportunities compared to solo travellers. Similarly, the combination of sparse population and long distances with elderly people also poses challenges for how to address their transportation needs. While smartphone penetration and technology knowhow is constantly growing, it is generally the older folk that have the most difficulties accessing services without human contact points (i.e. through mobile apps). Therefore, there is a demand for very versatile and flexible services but with a challenging business case.

Future solutions like automated vehicles are seen as a huge opportunity by cutting the major cost of the driver, and thus making the supply-side of the equation far more efficient, or by allowing the driver to perform or activities such as attending to the passengers or serving as a tour guide. However, there is plenty of work to be done before the vision may become a reality, particularly in rural areas where the infrastructure and conditions may be more lacking than in urban areas. In the next section we go through the results for the opportunities shared mobility services have in rural areas with current technologies.
Case study results: Shared Mobility Services in Rural Areas

The current changes in mobility strongly rest on digitalization that enables resource efficient and sharing economy through, for example, digital platforms focusing on efficient combinations and provision of mobility services. New resource efficient approaches require interoperable solutions and services which not only require a more comprehensive understanding of available solutions and customers’ needs, but also exploiting new value capturing models. As for mobility in rural areas where the distances are long and flow of goods and people is more sporadic, it has been noted that enriching typical transport services by integrating other transport-related services into a regular service portfolio could positively contribute to resource efficiency. These additional services can cover shared taxis, carpooling, city bikes and small parcel logistics services. For example, in Western Finland, the local mobility service provider (public-private collaboration) also strives to improve the statutory social service transportation services, i.e. trips for disabled and elderly persons etc., by connecting the organizations responsible for these trips to their service offering.

In general, this issue - improving publicly subsidized transport - has been widely debated in Finland since reformations of health and social services as well as regional governments are currently ongoing. For the regions to be established, transport and mobility is a crosscutting theme with a vital role. Public expenses on statutory social service transportation in Finland are currently over 1 billion euros and there is continual pressure to get them reduced even though simultaneously the accessibility of public transport should be improved in order provide sufficient service level through reorganized and complementary transport services for the citizens in rural areas. It is also worth noting that for many regions, such as Lapland, demand may be highly dependent on seasons (e.g., tourism) creating significant peaks and variation in the demand for public transport. This adds to the challenges of balancing supply and demand resource efficiently.

At the moment, international travel agencies manage and organize most of the trips for tourist groups and the packaged holidays typically include feeder transport to and from the airport as well as other transportation around the travel area by charter buses. However, an increasing trend towards individual traveling also increases demand for public transport and mobility services. Organising these services in rural areas calls for smart, resource efficient solutions in order to enable individual travelers to move to and around the area. According to interviews, rental car services and peer-to-peer car sharing services are seen as primary ones that seem to have development potential. In Lapland, especially peer-to-peer car and ride sharing have several benefits: (1) it is circular and sharing economy in its purest by maximizing the use of available resources, (2) P2P car sharing improves availability as the fleet of usual commercial rental cars is relatively small, and (3) ridesharing enhances accessibility by serving as a link to other transport services. It is also worth considering that in addition to peer-to-peer ridesharing, taxi rides can be shared too. From the tourists’ point of view, shared taxies are likely to be considered more reliable and safe than taking a ride from a stranger. The results from the Ylläs Around impact study show that the taxi entrepreneurs in particular saw a carpooling model as a valuable development direction as shared costs for the end users would make taxis more affordable and therefore increase the amount of customers. When it comes to the local people, P2P car and ride sharing appear to be a worthy option since they mostly know and trust one another. In addition to digital services, village communities can act as an organizer for the shared trips or cars. Then, however, the volume and the number customers may remain relatively small or limited at least.

Different kinds of flexible on-demand transport services, generally, are needed to take care the ad-hoc needs for transport. On-demand services can also serve as a feeder for main public transport lines to help coverage in sparsely populated areas where scheduled lines cannot cost-efficiently provide sufficient coverage.
According to Ylläs Around impact study, new types of mobility services tempt to increase the use of public transport and decrease the use of private cars by filling a missing gap. Similar results have been identified in the UbiGo service pilot in Gothenburg, Sweden, and the SMILE pilot in Austria.

If the business aspect of sharing economy in a rural context is considered, mobility and transport service providers will probably aim to increase the average vehicle occupancy and utilization rates as well as improving the accessibility of public transport by providing a set of on-demand first-/last-mile services. Naturally, public transport operators and other public actors should also focus on reducing the emissions in accordance with the political guidelines of the municipalities, region or the government. Also, cost savings for the public sector through improved efficiency and more inclusive services are quite an essential part of the rural mobility. It is possible that in rural areas, digital services and platforms enabling the integration of local commercial, (subsidized) public and shared private mobility resources would be implemented in order to ensure the availability, accessibility and sustainability of transport services for all the travelers.

One of the ways to improve the regional services would be combined (i.e. open) transport services for statutory social services with one another as well as with regular travelers (i.e. more than one person per car). Depending on the service provider or travelers’ needs the vehicle can either be a taxi, bus or minibusses of companies or public organizations. Combined public transport services have been studied and piloted in the Kainuu region, Finland by Kainuu Social Welfare and Health Care Joint Authority which is responsible for managing and organizing social and health care for ca. 75 000 people and 23 000 km². The region currently has four local centers (Kajaani, Suomussalmi, Sotka and Kuhmo) with commuter traffic, school transport etc. Currently, the public transport is mostly profitable in and around the municipal centers where most of the people live, but since the region is relatively large and sparsely populated the public transport between cities is heavily subsidized. At the same time, close to 80 000 annual rides organized and paid by the Social Welfare and Health Care Joint Authority are driven around the region. Since most of the trips are carried out by taxis with only one passenger, utilization rate has remained low. Therefore, the region and the Social Welfare and Health Care Joint Authority decided to launch a pilot that provided a change for private people to join in the organized taxi rides with paying only an excess fee that depends on the income of the customer or the family. Also, some school transports became public; since the school transport is mostly carried out by minibusses or buses, joining those rides only cost the regular public transport fee (6.10€). (Kainuu Social Welfare and Health Care Joint Authority, 2016).

The pilot aimed to study the potential impacts of “combined transport services” on public cost, accessibility of the transport services and the number of public transport passengers. The results indicate that combined transport could decrease the public costs and increase the accessibility. In Kainuu, it has been evaluated that combined, not publicly open, transport services have helped them to decrease the cost by at least 30%. (Kainuu Social Welfare and Health Care Joint Authority, 2016).

Another similar example comes from Tampere, Pirkanmaa, Finland, where the impacts of combined social statutory rides of the city of Tampere and Pirkanmaa hospital district were assessed. The results were significant: the daily driven kilometers could be reduced by 12 000km which annually means 400 000 tons less CO₂ emissions. In addition, 15% cost savings (4M€ of the current 26M€) could be reached, and there is potential for even greater savings if public transport (i.e., busses) and school transport is exploited in combinations too. (Liimatainen et. 2015).
DISCUSSION AND CONCLUSIONS

Circular economy applies to transport and mobility in many ways that can be linked to and reinforce one another. A distinctive issue in solving mobility needs efficiently is the fact that it is reliant on physical assets (i.e. vehicles and infrastructure). New, digital services provide new channels for discovering, accessing and using mobility services more effectively. On the one hand, the digital services have nothing to offer if the underlying transport is not available, and on the other hand, without smart services the possibilities of maximising the use and reuse of the resources is not possible.

We categorised the types of ways circular economy plays a part in transport and mobility in three broad categories that complement one another: (1) design innovations, (2) efficient reuse, and (3) digital services. The first two refer mainly to the effectiveness of the underlying transport and services while the third one addresses new ways of using them, turning the transport services into resource-optimising mobility services. In the paper, we then focused on sharing services that digital solutions can facilitate and combine and the challenges and opportunities they have specifically in rural areas.

Sharing economy refers to a market situation in which people share among them items and use of different services or resources. It is recognized as a global phenomenon impacting many consumer sectors, enabling new means of connecting people to share resources, assets and markets. Sharing has always been a part of transport. Hitchhiking and carpooling, for instance, have been relatively well known in rural areas, but pressures to decrease costs and at the very least maintain public transport service levels have led to seeking more sophisticated and alternative services. Different forms of car and ride sharing are all emerging services attracting new customers.

When it comes to transportation and areas with sparse population and long distances, the key sharing solutions we identified as showing the highest potential are (1) on-demand transport services, (2) shared taxis, (3) combined transport services for statutory social services, and (4) shared cars.

Accessibility is important for both inhabitants and tourists in rural areas. An appropriate service level can partly be enabled by on-demand services carried out with taxis, charter vehicles or regular passenger transport vehicles. On-demand solutions provide a passenger flexibility around the route they take and the time they travel. Particularly in rural and sparsely populated areas, the cost for scheduled daily transport can easily be too high compared to the passenger volumes. That is why rural on-demand services can be driven, for instance, once or twice a week if reservations have been made - or at any time a minimum amount of reservations is received. This also applies to a situation where on-demand services are used for the first/last-mile to extend or complement the public transport service networks to target customers living in areas outside the typical public transport service area. An on-demand service can also be exploited to connect rural areas to long-haul transport. In both of these cases, a taxi, for example, can be informed and pre-ordered to be waiting for the arriving passengers to take them to the final destination.

Shared taxis or shared commercial transport services, in general, seems to be the desired service in rural areas but applications making it easy are still needed. Compared to ride sharing and ride-hailing (P2P), for which it tends to be difficult making it a worthwhile (and from a regulatory point of view, legal) business case for all parties involved even in cities, taxis have an established business model that can be made more attractive by sharing the ride between multiple passengers.
As for shared cars, they might not always be the best choice for tourists who for example do not have experience in driving in winter conditions. However, shared cars from local businesses and private people, generally speaking, are a worthy option to supplement the fleet of traditional and commercial rental cars, which tends to be relatively small with high costs. Perhaps local workers or companies (e.g., at skiing resorts) could P2P-rent their cars to people with ad-hoc transport needs.

Combined and open transport services for statutory social services have significant savings potential as seen in the cases of Kainuu and Tampere. Potential does not just apply to monetary savings but also to savings in emissions, fuels, materials and human resources. The accessibility and the number of mobility services can be increased simultaneously which is a significant aspect considering the typical challenges of rural areas. On the other hand, social statutory transport services are mostly organized for special groups and people with severe disabilities and specific needs. Hence, special needs (e.g., accessible vehicles) and rights (e.g., combining prohibited for privacy) must be kept in mind when combining and opening those transport services is discussed. All the transport services cannot be opened for regular people or cannot even be combined with one another.

For those without specific restrictions for sharing the ride and resources, however, suitable services and incentives or compensation should be identified to create win-win situations (e.g. lower subsidized costs as well as lower cost paid by the individual). Other things to consider include accessible digital services since many seniors or people with disabilities are not capable of using modern digital services and applications. Hence applying design-for-all principles is recommended: if the service works with disabled people, it works with everyone. To find the most workable solutions and best practices, pilots and small experiments are highly recommended to distinguish which services are effective, for which user segments they are suited for and which special requirements should be taken into account in the implementation. Such results could be further utilized when scrutinizing the current legislation that to some extent hinders the combined transport services (Vesanen-Nikitin and Åkermarck, 2017; Eckhardt et al. 2017).

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MaaS = Sharing

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New concepts lead to disruptions

Thanks to the rapid technologies developments in the past decennium, disruptions have taken place in many business sectors. The telephone sector had to change its lucrative SMS business models when Whatsapp shook the grounds. The music industry has been struggling for many years with illegal digital music. With Spotify, new business models have been found.

To a certain extent, Spotify shows us the way for the future of the mobility. This service provides access to all music at any time, thus giving a huge added value above owning some music with your CD collection.

In the mobility sector, car ownership has been the default option in a car dependent society. If one has the need to use a car more or less often, he needs to own one. Worldwide a huge growth in carsharing can be noticed. Anyway, these shared mobility services mostly serve early adaptors, with characteristically low interest in cars and all the emotional affects that typically dominate the car industry. However, whenever access to mobility will give an added value above owning a car, a breakthrough could be foreseen in the mobility sector as well.

Smart mobility

Mobility is smart when sustainable transport modes like walking, cycling and public transport are the main transport modes:
- They are environmentally friendly;
- They need less space;
- They support healthy life styles;
- They increase the attractiveness of cities;
- They are faster in urban settings;
- They require substantially lower investments, while cities with low car use function better, resulting in stronger economies.

De Bremen Declaration (2016) includes eight main principles for mobility planning, amongst which:
1. efficient use of public space;
2. focus on people instead of vehicles;
3. usage instead of ownership.

The same principles apply for businesses. The more sustainable their transportation, the lower the mobility costs, the lower their CO2 emissions and the higher their spatial quality which may be translated in a higher property value.
Mobility as a Service = Shared Mobility

Shared mobility is an important condition for MaaS. When users want to have access to different forms of mobility, these means have to be accessible in a flexible way. And there we find shared cars and bikes, rental cars, taxis and other forms of shared mobility. Such solutions have to be tied together into a complete package.

Tools like the Sparc and smart bicycles locks make it easy to share fleets and to register trips and driving behavior. By this, cars and bikes become shareable.

With an online reservation platform all kind of assets can be shared, from cars, bikes and parking spaces till workplaces and meeting rooms.

Within the INTERREG project SHARE-North, Advier tied together these aspects in a service package that can handle the total demand for transportation. In a couple of living labs Advier is experimenting with this MaaS approach. The main vision is to serve real estate parties which have a long-term interest in accessibility. MaaS could increase real estate values while it needs structurally lower investments in parking facilities.
Living Lab: Technology Base Twente

The former Twente airport is being redeveloped and innovative companies will have the opportunity to innovate and to experiment. Advier developed a proposal for a flexible mobility package based on the above described concept. The property owner uses the MaaS concept to better sell their proposition for their relations. The basic idea is property value increases when accessibility is higher. The MaaS concept can be integrated in the rental prize. By this a offer can be realized with all kind of transport options, including carsharing, bike sharing, Segways, drones for package delivery and driverless shuttle services. The system can develop in pace with the development of the business park. At peak times, e.g. during large events, it’s easy to scale up the system in order to fulfill the demand for transport. Compared to traditional public transportation with fixed lines, frequencies and capacities, the possibilities are huge.

Discussion: who owns MaaS?

The big challenges are not technologically oriented, since technology is fully available. The real challenge is organizationally. Organizational questions include:

• How to develop the spatial concept of the area in a way that supports the use of MaaS in favor of the private car?
• Who owns MaaS? If it’s the government, should it be organized nationally or regionally, or both? Or should the government organize the frameworks and the infrastructure within which market operators could operate?
• Should PT-companies or PT authorities own MaaS? MaaS provides a way to improve the PT service level. On the other hand, the main transport modes remains PT while for real estate services PT is just one of the options.
• Or should service providers own MaaS? And should actors like Tesla, Uber or Google let governments lead the developments?
• In the end, do we need PT authorities, when service providers can realize a better transport offer than the government does. Should the strategy be to develop MaaS as a ‘plus’ service to PT, or as a service that provides a better travel option than PT?
• At least, PT operators should make it possible to be related to MaaS service providers that want to include PT trips in their offer to the end user.